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SEVENTEENTH ANNUAL REPORT
OF THE
BOSTON WATER BOARD



FOR THE
YEAR ENDING JANUARY 31, 1893.

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FOR THE

Year ending January 31, 1893.

Printed for the Department.



BOSTON :

ROCKWELL AND CHURCHILL, CITY PRINTERS.

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Boston Water Board,

June 24, 1893.

OFFICE OF THE BOSTON WATER BOARD,
CITY HALL, BOSTON, February 1, 1893.

HON. NATHAN MATTHEWS, JR.,
Mayor of the City of Boston:

SIR: The Boston Water Board, or Water-Supply Department, submit their annual report for the financial year ending January 31, 1893.

The following is a comprehensive summary of the disbursements by the department for said year:

Money expenditures, Cochituate Water-Works (see page 23)	\$947,842 39
Money expenditures, Mystic Water-Works (see page 24)	118,949 83
	\$1,066,792 22
Add decrease in stock during year (see page 25)	3,981 61
	<u>\$1,070,773 83</u>

Current expenses, Cochituate Water-Works	\$350,743 68
Current expenses, Mystic Water-Works	120,205 50
Extension of mains, etc.	221,992 71
Additional supply of water	313,844 53
High service	63,987 41
	<u>\$1,070,773 83</u>

We submit a brief summary of the principal facts of interest in relation to the work of the department, together with a detailed statement of the doings and condition of the separate divisions.

REVENUE.

The total receipts of the Cochituate Works from all sources for the twelve months ending January 31, 1893, have been \$1,457,936.37, of which amount \$1,433,413.78 was received from sales of water. The total receipts of the Mystic Water-Works from all sources for the same period have been \$395,792.47, of which \$394,008.75 was from sales of water; of this amount the sum of \$137,621.36 was paid to the cities of Chelsea, Somerville, and Everett, under their several contracts with the city of Boston. Water has been furnished for street-sprinkling without charge to the Street Department, and the charge for hydrants to the Fire Department has been reduced from \$15 to \$2 per hydrant or fire reservoir, a reduction in Cochituate and Mystic revenue from the Fire Department equal to \$63,371.00.

By Chap. 213, Acts of 1892, the Water Board was authorized to charge the purchase and laying of pipes to revenue, after the expenses and charges of distribution, the interest on the outstanding water loans, and the sinking-fund charges have been paid. Consequently, the Board has been required to expend from loan for extension of mains during the past year only \$134,566.78. The remaining cost of extension of mains, \$87,425.93, has been paid from the surplus revenue.

EXTENSION OF MAINS.

Nearly eighteen miles of pipe mains have been laid during the year, and the total length now connected with the works is 535.87 miles; 2,447 service-pipes have been laid; 203 hydrants have been established, and 53 abandoned; and the total number of hydrants now in service is 5,853.

In accordance with the practice in many other cities, a rule was adopted January 1, 1893, charging the cost of all new service-pipes hereafter to the water-taker.

The Board has also adopted the policy of charging the cost of extensions of the high-service mains for the supply of automatic sprinklers or fire-pipes to the parties asking for such extensions.

At the request of the Board of Health, in order to pro-

vide the proposed cholera hospital on Gallop's island with water, 2,874 feet of six-inch pipe was laid on Long island, and from its terminus a temporary wrought-iron pipe was laid under water from Long to Gallop's island. This work was done by contract. A 30-inch main was laid from the junction of Tremont street and West Chester square, through East Chester park and Swett street to Boston street, at Washington Village, South Boston.

JAMAICA POND AQUEDUCT CORPORATION.

By Chap. 371, Acts of 1892, the city was authorized to take, through the Park Commissioners, by purchase or otherwise, Jamaica pond and Ward's pond as a public park, and in pursuance thereof the real estate, pumping-station, etc., of the Jamaica Pond Aqueduct Corporation was acquired by the city, January 10, 1893. At the same time the Water Board bought the pipe system of the Jamaica Pond Aqueduct Corporation, by which the citizens of the Roxbury District were chiefly supplied with water. The price paid for the entire property was \$125,000, of which the Water Board paid \$75,000. When possession was taken, the Jamaica pond water was shut off and the Cochituate and Sudbury water turned on, and the citizens of Roxbury are now supplied solely with Cochituate and Sudbury water. The pipe system purchased from the Jamaica Pond Company includes about nine mile of pipes in what is known as the Roxbury District. The city has had parallel pipes in some of these streets, but the district has been chiefly supplied by the Jamaica Pond Company, the rates of which have been slightly less than the city rates.

The Jamaica Pond Aqueduct Corporation, which has thus ceased to exist as a water company, was incorporated February 27, 1795. By an act of the General Court, Luther Eames, Nathan Bond, and William Page, and their associates, were vested with corporate powers for the management and direction of the business, as a company, of bringing fresh water into the town of Boston by subterraneous pipes. By a subsequent act, June 10, 1796, this corporation was empowered to assume the title of "The Aqueduct Cor-

poration." The corporation was authorized to bring from any part of the town of Roxbury into the town of Boston all such fresh water as they, the said Luther Eames, Nathan Bond, and William Page, and their associates, in their private and natural capacities then had or hereafter should have a right to dispose of or to convey from the springs or sources thereof. The water was brought from Jamaica pond through four main pipes of pitch-pine logs, two of four inches bore and two of three inches, the lateral pipes having a bore of one and a half inches. The lineal extent of the water-pipes in Boston was about fifteen miles, and they reached north as far as Franklin street, and branched off easterly through Harrison avenue into Congress street, nearly to State street and to Broad street. They also branched off westerly through Pleasant and Charles streets, extending as far as the Massachusetts General Hospital, which was supplied with Jamaica-pond water. The capital of the company, so far as can be ascertained, was about \$130,000, or about \$1,300 a share, but the shares became much depreciated in value. In 1840 this company laid a ten-inch iron pipe from the pond to Bowdoin square. (The foregoing statement is compiled from one of the articles in Dr. N. B. Shurtleff's "Boston in the Olden Time," as quoted on pages 2-3 of the "History of the Introduction of Pure Water into the City of Boston," by Nathaniel J. Bradlee (Boston, 1868), and from Mr. Bradlee's text.)

When, in 1836, the acquisition and introduction of a supply of water by the city of Boston was being considered, the aqueduct corporation presented a memorial to the city government offering to supply the city with "ten times" the quantity of water furnished "upon any reasonable assurance that your memorialists will have no reason to fear any more formidable competition than that of a private corporation." "On the other hand, should the city of Boston decide that it will furnish a supply of pure water to the citizens, itself, your memorialists hereby tender their water-works to the city for a reasonable compensation." In October, 1846, after the passage of the Cochituate Water Act, memorials were received from Edward A. Raymond and others and from Josiah Bradlee and others respecting the supply from Jamaica Pond, and asking the city to adopt such measures as may be deemed expedient to relieve them from the present difficulty in obtaining a supply of water. These were referred to the Committee on Water of the City Council, which, on December 17, reported that they considered the petitions equivalent to a request that the city should purchase the Jamaica Pond Aqueduct under the authority

granted in the Water Act (Sect. 16, Chap. 167, Acts of 1846), and that they had applied to the Water Commissioners to obtain their opinion as to its value; and that the Water Commissioners in their reply recommend its purchase if it can be made for the sum of \$80,000; that this price is the estimated value of the property and franchise in the hands of the present proprietors, after introduction of water by the city, but that it would be of greater value to the city. [See Bradlee's History, pages 18-19, 65-66. Also City Documents, 1846, on water, Nos. 14½, 20, 21, 26, 32, 47.] November 10, 1848, the directors of the Jamaica Pond Aqueduct Corporation sent a memorial to the City Council praying the city to purchase the property, in which they said "that they do not ask redress as equals, who suffer in competition with equals, but as a few private individuals who are sacrificed on the altar of public accommodation, — a very few, whose property is destroyed for the whole remainder." This was referred to the Committee on Water, who reported December 14, recommending the desired purchase for the sum of \$75,000, and an order was passed authorizing the same in one branch of the City Council, but it was non-concurred in by the other. [Bradlee, page 81.] January 27, 1851, a memorial was received from the Jamaica Pond Corporation asking for a hearing in regard to the sale of their property to the city, which hearing was granted on March 26. On April 2 the Cochituate Water Board voted to offer to the corporation the sum of \$45,000 for their property, including all claims for damages. This offer was accepted by the corporation on April 30, and after a question raised by the City Council as to whether the Board had the power to make the purchase had been disposed of by the City Solicitor, the purchase was completed June 12, 1851, by the payment of \$45,217.50, in return for "a deed of all the property, estate, rights, and privileges of the corporation, and all debts due it since April 30, last, and a release to the city of all claims." [Bradlee, pages 138-140.]

During the year 1852 the city of Roxbury offered to purchase the Jamaica Pond Aqueduct from the city of Boston for \$35,000; but the offer was not accepted. In 1853 an offer of \$28,000 for the property was made by Eliphalet Baker, again on May 24, 1854, \$27,500, and on May 31, of the same year, \$30,000; but these several offers were declined. In 1856 it was decided by the Cochituate Water Board that it was best to sell the property known as the Jamaica Pond Aqueduct, with the condition "that no water should be supplied within the present limits of the

city of Boston," and the president was authorized to advertise for proposals for the same. The reason for coming to this conclusion was, that "all the objects for which the purchase was originally made had been or would be accomplished," namely: "*First*, To be rid of rival works; *second*, To quiet all claims for injury to their pipes by laying down our pipes; *third*, To annul the privilege of breaking up and injuring the streets, whenever and wherever they saw fit." In answer to the advertisement, Messrs. George H. and T. B. Williams, of Roxbury, made an offer of \$32,000 for the property, which was accepted, and the property passed out of the ownership of the city. [See Bradlee, *passim*, pages 149-176.]

Roxbury was annexed to Boston in 1868, and question having arisen as to the exclusive right of the Jamaica Pond Aqueduct Corporation to lay pipes in Roxbury, the City Solicitor gave an opinion March 24, 1868, that the Jamaica Pond Company "has no exclusive right to supply water" to Roxbury, and that "the city has full right to lay pipes and furnish the Cochituate water to all persons within the limits of that territory who choose to take it." December 3, 1869, a communication was received by the Cochituate Water Board from the Jamaica Pond Aqueduct Corporation offering to sell the property to the city for \$225,000. It was voted not to accept the proposition. February 18, 1871, a committee was appointed to consider the expediency of purchasing the property. October 12, 1874, a petition was received by the City Council from a number of citizens of Ward 17 asking the city to purchase Jamaica pond and supply Ward 17 from that source. The communication was referred to the Committee on Water, who obtained a written opinion as to the value of the property and the best methods of supplying the West Roxbury and Brighton districts with water, from the City Engineer, and subsequently reported that the price (\$200,000) asked for that property was more than its real value (City Document, No. 108, 1874). [See History of the Boston Water-Works, 1868 to 1876, by Desmond Fitzgerald, *passim*, pages 3, 12, 19, 55.]

The matter of purchase was mooted by the city government of 1880; but no action was taken. In 1881 the Jamaica Pond Corporation offered to sell the property to the city for \$100,000, or to have price fixed by the city, the city to choose all referees if desired. This offer was repeated in 1882; but no action was taken. February 11, 1886, the corporation again offered to sell the property to the city for \$100,000 and taxes for the current year, or at such price as should be fixed by three disinterested men, — one named by

the city, one by the corporation, and the third by the two so chosen. March 17, 1887, this offer was substantially repeated, and on March 22 the Water Board wrote to the Aqueduct Corporation that the Committee on Water had requested them to state that the committee would recommend to the City Council the purchase of the property for \$75,000 if the corporation would sell for that price. This offer was refused by the corporation, March 24. June 6, 1889, an order was passed by the Common Council requesting the Water Board to report to that body as to the advisability of purchasing the property. June 10, 1889, the Water Board wrote to the corporation to inquire for what sum the corporation would sell its property and franchises, and on June 11 received an offer to sell for such sum as three disinterested persons should name, or \$100,000 and taxes. June 13 the Water Board transmitted this offer, with a communication, to the Common Council, urgently recommending the purchase. May 11, 1891, the Water Board wrote to the Aqueduct Corporation to inquire if the corporation was ready to renew the offer of June 11, 1889, and on May 11 received a reply that the corporation would sell its property and franchises for such sum as might be awarded by three disinterested referees. May 25 the Water Board wrote to the Mayor, renewing its arguments, and calling attention to the fact that the Park Department wished to acquire the real estate of the corporation for park purposes, and the communication was transmitted by the Mayor to the City Council with a recommendation that the property be purchased. The passage by the Legislature of Chap. 371, Acts of 1892, above referred to, enabled the Park Department to purchase the real estate without an order from the city government, and the pipe system was bought by the Water Board at the same time by agreement with the Park Commissioners.

CONSUMPTION OF WATER.

The rainfall during the past year was the smallest since 1883, and the statistics show a large percentage of increase in the amount of water consumed. The daily average consumption per head of population on the Sudbury and Cochituate supply the past year was 95.3 gallons, and on the Mystic supply 78.6 gallons, as against 89.3 and 74.7 the previous year. The daily average consumption was 41,312,400 gallons on the Cochituate and Sudbury, and 9,810,800 on the Mystic, as against 37,686,900 and 9,055,200 respectively in 1892.

HIGH-SERVICE PUMPING-ENGINE.

On June 8 a contract for \$120,500 was made with N. F. Palmer, Jr. & Co., of New York, for building and erecting a new high-service pumping-engine for the Chestnut-hill Pumping-station, to be constructed in accordance with plans prepared by Mr. E. D. Leavitt. This engine, which will have a pumping capacity of 20,000,000 gallons in twenty-four hours, will be completed within a few months, and will be an important and necessary addition to the plant. Owing to the rapid growth of the city and the increasing number of tall buildings, the demands upon the high service have become so great that at times both of the present engines now in service, each of which has a pumping capacity of 8,000,000 gallons, have to be worked. The policy in most cities is to deliver water in the basement of buildings, and oblige the water-takers to pump it to the upper stories, but the water-takers of Boston have become accustomed to expect that water will be made to flow freely in the tops of the highest buildings without the assistance of pumps, tanks, adequate plumbing, or any of the appliances which the water-takers of New York and other places expect to provide at their own expense. It is extremely doubtful if the city can afford to continue the policy of providing a pressure that will send water to the top story of the highest buildings, and certainly it would seem reasonable that those who erect high buildings should protect themselves by suitable appliances against the falling off in the pressure certain to occur at times of excessive consumption, as during the present cold winter.

BASIN 6.

The work of construction on Basin 6 was continued from early in April until the end of the season. The dam was raised 21 feet, both gate-chambers were built to grade, valves were placed in the lower gate-house, and the wasteway was completed. Of the work of stripping, the contracts for sections A, B, and C have been completed, and both D and E are nearly completed. The contract for E was let January 13, 1892, to John Berry & Co., for 40 cents per cubic yard, on an estimated amount of \$47,786. By the end of another season this basin will be finished and ready to be filled during the winter of 1893-94.

ADDITIONAL BASIN.

It is important that the work of constructing a new basin on the Sudbury water-shed be begun at once. The plans and

surveys for this basin are being made, and the lands for the same will be taken as soon as the necessary funds are provided by the City Council. A loan order for \$2,500,000 was introduced January 2, 1893, and has passed one branch of the city government. This sum will be required for the construction of this large basin, which will have a capacity of about 12,500,000 gallons daily, — nearly three times the capacity of Basin 4 or 6. In view of the large increase in consumption of water, indicating the rapid growth of the city, it is imperative that there be no delay in building this basin. In the event of a series of dry years we should not have more than sufficient water for the needs of the city, even including the supply from Basin 6, which will not be available until 1895. It will take about five years to complete a new basin.

MEASURES TO IMPROVE THE QUALITY OF THE SUPPLY.

The sewerage systems of the city of Marlboro' and the town of Westboro' have been completed, and the sums due these communities under our contracts with them have been paid, and both of these systems are working satisfactorily. As we stated in our report a year ago, decided improvement in the quality of the water of Basin 3 is likely to result from this removal of a large portion of the sewage of Marlboro' from the water-shed of the Stony-brook branch of the Sudbury. Although the sewerage system of Framingham has been in active operation for about three years, we have up to this time declined to pay the \$25,000 which by the terms of the contract the city of Boston was to pay on the completion of the system, for the reason that the surface-water of the town of Framingham, contrary to the plans approved by us, is allowed to flow under the sewer into a brook tributary to our water supply. The authorities of Framingham have been considering the best method of diverting this surface-water so that it may cease to be a source of possible future danger to the city of Boston, and plans are now being prepared with a view to a final disposition of the matter in a satisfactory manner. We are glad to report that the town of Natick has recently submitted to us plans of a proposed sewerage system for that town. These plans have been carefully considered by us, and we have written to the authorities of Natick, that on the condition that certain minor modifications be made therein, the Water Board will advise the City Council of Boston to appropriate a specified sum by way of contribution to the expenses of the system.

The Board has directed the City Engineer to prepare

plans for the filtration of the water of Pegan brook, which work will be undertaken early in the spring. The water of this brook has been steadily improving, but in view of the fact that some time must elapse before a sewerage system for Natick can be completed, we have deemed it wise to undertake this improvement in order to avert any possible dangers of pollution during the coming season. Work will also be begun on the important scheme of draining Cedar swamp at the head-waters of the Sudbury supply, to which reference was made in our last report. It was not practicable to begin work in 1892, owing to the serious engineering difficulties involved. On the Mystic arrangements have been entered into with the proprietor of a large tannery at Stoneham for chemically treating and subsequently filtering the sewage from his premises, with a view to treating the sewage from other tanneries in the same manner, if this experiment prove successful.

FILTRATION OF THE MYSTIC SUPPLY.

Special attention is called to the accompanying report of the City Engineer, wherein he recommends the filtration of the Mystic supply. The Water Board have at various times in their annual reports stated that the Mystic water was far from satisfactory in its present condition, and intimated that it might become desirable to abandon it. As the result of a series of experiments authorized by this Board, the Engineer estimates that by an expenditure of five hundred and seventy-five thousand dollars (\$575,000), a satisfactory filtration plant can be built on the shore of Mystic lake. It will also be necessary to build a new engine, boilers, and engine-house, at an estimated cost of \$150,000, if the Mystic system is to be retained. At present Charlestown is the only portion of Boston supplied with Mystic water. This district uses only about 3,000,000 gallons daily. We supply, however, Everett, Chelsea, and Somerville, by contract, with Mystic water, and the amount of water consumed by Charlestown, Everett, Chelsea, and Somerville combined is at present greater than the natural yield of the Mystic supply in a period of drought, which is only 7,000,000 gallons daily. This year these communities used a daily average of 9,810,800 gallons. These communities are growing, and there will not be enough water for all of them for any great length of time, or whenever we have a dry series of years. If the city of Boston is to retain the Mystic supply, we should at once be authorized to expend the necessary sum for making the water wholesome, and providing a suitable pumping plant.

CAPACITY OF DISTRIBUTION SYSTEM FOR FIRE PURPOSES.

Early in the year the Board requested the City Engineer to make investigations as to how the water-pipe system for protection against fire of Boston compares with the systems in other large cities of the United States, and a competent representative was sent to make personal inspection of the resources of New York, Brooklyn, Philadelphia, Baltimore, Washington, Pittsburgh, Cincinnati, St. Louis, Chicago, Detroit, and Cleveland. The results of this inspection, which appear in the accompanying report of the City Engineer, and which will repay careful examination, establish conclusively that Boston is at least not second to any of the other cities of the country in the capacity of its water-pipe system for supplying water to extinguish fires. Plans of the entire city, dividing the city into districts, and showing the capacity of the distribution system at every point, have been prepared and furnished to the Fire Department.

THE FUTURE OF THE SUPPLY.

As regards the future of the supply, the Water Board on December 2, 1892, submitted the following special report to the Mayor. The table thereto appended shows the population of Boston and its suburbs from 1850 to 1890, with estimated population from 1890 to 1920, also the population within the present city limits, and the population of metropolitan districts within six and ten miles of City Hall. In our report of last year the Board called attention to the fact that by the end of ten years the capacities of the Sudbury will be exhausted, and that the needs of the cities and towns neighboring to Boston will probably have to be considered in connection with any problem of a new source of supply for Boston. As no funds are at the disposal of this Board for the prosecution of independent investigations, and as the interests of other committees are likely to be concerned, it seems to us desirable that the Legislature should authorize the appointment of a metropolitan commission for the consideration of this question.

OFFICE OF THE BOSTON WATER BOARD,
CITY HALL, BOSTON, December 2, 1892.

HON. NATHAN MATTHEWS, JR.,
Mayor:

SIR: The Boston Water Board has the honor to submit the following statement regarding the quantity of the water supply and the immediate and prospective needs of the city as regards the future development of the Sudbury system by the construction of additional basins, and the necessity of considering the problem of a new source of supply.

Basin 6, so called, on Indian brook, now in process of construction, will be completed by the end of another year, adding about four million gallons daily to the supply.

In order to avoid the certainty of a scarcity of water in case of drought, the work of constructing a new and much larger basin on the Sudbury river should be begun forthwith.

When the special report of March, 1888, was made by the Water Board and City Engineer, it was figured that the full development of the Sudbury and Cochituate system would yield only 49,000,000 gallons daily, but as appears from the communication of the City Engineer, hereto annexed, later and more thorough investigations justify the confident statement that this yield can be increased to 67,000,000 gallons daily.

It appears from these studies that two basins of very large capacity can be built, one on the Stony-brook branch and one on the main stream of the Sudbury river, each of which will add from ten to twelve million gallons daily to the supply, and the cost of either of which will be about \$2,500,000.

The cost of building Basin 6 will be about two hundred and twenty-five thousand dollars (\$225,000) per one million gallons net daily yield, while for a new and larger basin, as designed, the cost per one million gallons net daily yield will be less than two hundred thousand dollars (\$200,000).

This decrease in estimated cost is due to the fact that a basin on a very large scale can be built at a less cost than a smaller one, provided the other conditions are not dissimilar.

A new basin can be built in from five to seven years without an increase in the net water debt.

Of the \$1,045,000 loan for additional water supply, approved November 13, 1889, the balance December 1 (\$227,495.14) remaining will be necessary for the completion of Basin 6 and for the settlement of the damages that may be awarded in consequence of the taking of Whitehall pond.

Accordingly for this new work a new loan is necessary, and we respectfully request that our necessities may be laid before the city government.

The advantages accruing from the construction of a new basin will be not only to increase the supply of the city in time of drought from ten to twelve million gallons daily, but also materially to increase the purity of the water, and on this point the Board cannot speak too forcibly.

When one additional basin is completed the city will have a supply of from 51,000,000 to 53,500,000 gallons daily, which, according to the estimates of the increase of population hereto annexed, will no more than meet the requirements of the district now supplied by the Sudbury and Cochituate systems in the year 1900.

By further developments, such as raising the dam at Whitehall pond eight feet, raising the dam at Lake Cochituate, improving Basin 1, and building a compensating reservoir to supply the 1,500,000 gallons daily which are required by law to be sent down the Sudbury below Dam 1, and the possible construction of a second new basin on the Sudbury system, the combined supplies can be made to furnish 67,500,000 gallons daily, which, according to an estimated four per cent. annual increase over the consumption in 1890, would be the supply required in 1905, provided that no additional territory than at present be supplied from the Sudbury and Cochituate system.

It may be said that while the construction of one new basin is imperative in order to develop the Sudbury system to meet present needs and also to serve as an adjunct to any future supply of the city, further investigations may prove that a second basin cannot be advantageously

built, in which case the ultimate capacity would be reduced ten million gallons daily.

It will be seen that we are rapidly nearing the time when a new source of supply must be provided, and we take this opportunity to call public attention to the fact.

In connection with the problem of any new supply for the city of Boston, the requirements of adjacent cities and towns may well be taken into account, as their rapid growth will soon render their present supplies inadequate.

In this connection we call attention to the annexed table, showing the population of Boston and its suburbs from 1850 to 1890, with estimated population from 1890 to 1920.

Very respectfully,

BOSTON WATER BOARD,

By ROBERT GRANT,

Chairman.

CITY OF BOSTON, ENGINEERING DEPARTMENT,

50 CITY HALL, December 2, 1892.

MR. ROBERT GRANT,

Chairman Boston Water Board :

SIR: In compliance with your request, the following estimate of the ultimate capacity of the Sudbury and Cochituate water supplies have been prepared. The increased capacity over that shown by the estimate of March 3, 1888, is mainly due to the enlargement of the proposed basin on the Stony-brook branch, No. 5, and to a projected basin to be made by excavating Cedar swamp; later surveys and studies having shown that the increased development is possible.

The estimate of the capacity of the different basins has been made without any allowance for water stored in the ground surrounding them, and is as follows:

	Present Capacity.	Ultimate Capacity.
Lake Cochituate	9,700,000	12,300,000
Basins 1 and 2, and Farm pond	10,100,000	6,700,000
Basin 4	5,200,000	5,200,000
Basin 6		4,700,000
Cedar swamp		12,300,000
Whitehall pond	3,300,000	3,300,000
Basin 3	9,200,000	4,800,000
Basin 5		17,100,000
	37,500,000	67,400,000
Compensating reservoir		1,500,000
		68,900,000

The net increase due to the different improvements is as follows:

Raising Whitehall pond 8 feet	1,000,000
Cedar swamp basin	9,900,000
Basin 5	12,700,000
Basin 6	3,700,000
Raising Lake Cochituate	2,600,000
	29,900,000

These results, however, can only be obtained in actual practice by the most skilful management.

Appended is a table showing population of Boston and its suburbs from 1850 to 1890, with estimated population from 1890 to 1920, also the total population within the present city limits and the population of metropolitan districts within six and ten miles of the City Hall.

Yours respectfully,

(Signed)

WILLIAM JACKSON,
City Engineer.

We append tables showing in detail the expenditures for the financial year, the condition of the water debts, and of general statistics, etc.

Respectfully submitted,

ROBERT GRANT,
JOHN W. LEIGHTON,
THOMAS F. DOHERTY,
Boston Water Board.

TABLE SHOWING POPULATION OF BOSTON AND ITS SUBURBS FROM 1850 TO 1890,
With Estimated Population from 1890 to 1920, also the Total Population within the present City Limits, and the Population of Metropolitan Districts within Six and Ten miles of the City Hall.

	1850.	Per cent. Increase.	1855.	Per cent. Increase.	1860.	Per cent. Increase.	1865.	Per cent. Increase.	1870.	Per cent. Increase.	1875.	Per cent. Increase.	1880.	Per cent. Increase.	1885.	Per cent. Increase.	1890.	Per cent. Increase.	1895.	Per cent. Increase.	1900.	Per cent. Increase.	1905.	Per cent. Increase.	1910.	Per cent. Increase.	1915.	Per cent. Increase.	1920.
City Proper	113,721	11.1	126,296	5.75	133,563	5.6	141,083	. . .	138,781	1.4	140,669	4.5	147,075	. . .	147,138	9.05	161,330	3.	166,170	3.	171,500	2.	174,580	2.	178,070	2.	181,630	2.	185,260
East Boston	9,861	61.9	15,963	21.25	19,356	13.9	21,872	16.7	25,516	15.0	29,347	1.9	29,926	5.0	31,419	17.5	36,330	15.	42,470	15.	48,840	10.	53,720	10.	59,100	10.	65,000	10.	71,500
South Boston	13,309	27.1	16,912	47.35	21,921	17.8	29,363	33.5	39,215	38.1	54,147	4.1	56,369	9.2	61,534	8.5	66,791	10.	73,470	10.	80,820	10.	88,900	8.	96,000	8.	103,700	8.	112,900
Roxbury	18,364	0.6	18,469	36.1	25,137	13.1	28,420	22.2	34,753	45.1	50,429	13.3	57,123	15.5	65,965	18.9	78,411	15.	90,170	15.	103,700	15.	119,250	10.	137,140	10.	150,850	10.	165,940
Dorchester	7,969	4.7	8,340	17.1	9,769	9.7	10,717	14.3	12,261	28.8	15,788	13.3	17,890	15.8	20,717	43.1	29,638	33.	39,500	25.	49,400	25.	61,740	20.	74,080	20.	88,900	20.	106,680
West Roxbury			4,812	31.1	6,310	9.5	6,912	25.7	11,783	19.1	11,783	24.2	17,424	43.5	24,997	33.	33,330	30.	43,330	25.	54,170	20.	65,020	20.	78,020	20.	93,630	20.	106,680
Brighton	2,356	22.9	2,895	16.6	3,375	14.2	3,854	28.9	4,967	24.8	6,200	8.0	6,693	27.3	8,523	41.2	12,032	33.	16,040	33.	21,390	25.	26,710	23.	33,420	20.	40,100	20.	48,130
Charlestown	17,216	26.5	21,700	15.5	25,065	5.3	26,399	7.3	28,223	18.5	33,556	0.5	33,731	8.7	36,673	1.8	38,348	2.	39,100	2.	39,900	2.	40,700	2.	41,500	2.	42,340	2.	43,180
Total	182,796	17.8	215,387	14.9	247,496	8.5	268,626	8.9	292,502	16.9	341,919	6.1	362,839	7.6	390,393	14.9	448,477	11.6	500,250	11.7	558,880	10.9	619,800	10.4	684,230	9.7	750,540	10.1	826,320
Somerville	3,540	64.0	5,806	38.2	8,025	16.55	9,333	57.0	14,685	48.9	21,868	14.0	24,933	20.2	29,971	34.0	40,102	23.	50,190	25.	62,740	20.	75,290	20.	90,340	20.	108,400	20.	130,990
Chelsea	6,791	51.5	10,151	32.0	13,395	7.5	14,403	28.8	18,547	11.8	20,737	5.0	21,782	18.0	25,709	8.6	27,969	15.	32,100	15.	36,910	15.	42,450	10.	46,690	10.	51,300	10.	56,500
Everett									2,220	64.5	3,651	13.0	4,119	40.1	5,823	90.	11,068	40.	15,800	40.	21,830	30.	28,380	30.	36,900	25.	46,100	25.	57,640
Cambridge	15,215	34.6	20,473	27.3	26,060	11.7	29,112	36.1	39,634	20.7	47,838	10.1	52,669	13.3	59,638	17.4	70,028	15.	80,500	15.	92,000	15.	106,500	15.	122,480	15.	140,850	15.	154,930
Brookline	2,516	49.5	3,737	38.2	5,164	1.9	5,262	26.4	6,650	0.4	6,675	20.7	8,067	14.1	9,199	31.6	12,032	30.	15,730	25.	19,660	25.	24,580	20.	29,500	20.	34,400	20.	42,480
Malden	3,820	30.45	4,592	27.7	5,565	16.6	6,840	7.7	7,567	47.2	10,813	10.8	12,017	36.5	16,407	40.4	23,031	40.	32,240	40.	43,140	30.	58,080	30.	75,280	25.	94,100	25.	117,630
Medford	3,740	22.8	4,603	5.2	4,842	. . .	4,830	18.1	5,717	15.9	6,627	14.3	7,673	19.4	9,042	22.5	11,079	20.	13,300	20.	15,950	20.	19,150	20.	23,000	20.	27,570	20.	33,100
Revere	935		793						1,197	33.9	1,603	41.2	2,263	60.7	3,637	55.8	5,668	40.	7,930	40.	11,100	40.	15,550	30.	20,200	30.	26,300	30.	34,160
Winthrop			407	33.6	544	16.3	633		532	17.9	627	66.3	1,043	31.3	1,370	99.0	2,726	50.	4,090	50.	6,130	40.	8,580	30.	11,150	25.	13,940	25.	17,430
Total, 6 miles radius	218,972	21.4	265,949	17.4	312,312	8.8	339,926	14.4	389,051	18.9	462,388	7.6	497,335	10.8	551,208	18.4	652,241	15.3	751,930	15.8	870,940	14.7	998,980	14.1	1,139,870	13.6	1,294,560	13.6	1,470,280
Newton	5,258	28.7	6,768	23.8	8,382	7.1	8,975	42.9	12,825	25.6	16,105	5.5	16,995	16.3	19,759	23.4	24,379	20.	29,250	20.	35,100	20.	42,120	15.	50,550	15.	58,130	15.	66,850
Hyde Park									4,136	52.7	6,316	12.2	7,088	18.2	8,376	21.7	10,193	15.	11,720	15.	13,470	15.	15,500	15.	17,820	15.	20,500	15.	23,570
Quincy	5,017	18.0	5,921	14.5	6,778		6,718	10.8	7,442	23.	9,155	15.5	10,670	14.9	12,145	37.7	16,723	25.	20,900	25.	26,130	25.	32,660	20.	39,200	20.	47,030	20.	56,440
Melrose	1,260	56.8	1,976	28.1	2,532	13.10	2,865	19.2	3,414	16.8	3,900	14.3	4,560	33.8	6,101	39.6	8,519	33.	11,360	33.	15,150	30.	19,700	30.	25,600	25.	32,000	25.	40,000
Arlington	2,202	21.25	2,670	0.4	2,681	2.95	2,760	18.1	3,261	19.8	3,906	4.9	4,100	14.0	4,673	20.5	5,629	20.	6,750	20.	8,100	20.	9,730	20.	11,700	15.	13,440	15.	15,450
Watertown	2,837	26.1	3,578		3,270	15.6	3,779	14.5	4,326	17.8	5,099	6.5	5,126	16.0	6,238	13.4	7,073	15.	8,130	15.	9,330	15.	10,750	15.	12,360	15.	14,200	15.	16,300
Belmont					1,198	6.7	1,278	18.4	1,513	28.	1,937		1,615	1.5	1,639	28.	2,098	20.	2,520	20.	3,020	20.	3,620	20.	4,330	20.	5,220	20.	6,260
Waltham	4,464	35.5	6,049	5.75	6,397	7.8	6,986	31.4	9,665	9.7	9,945	17.8	11,712	24.7	14,609	28.1	18,707	25.	23,380	25.	29,230	25.	36,510	20.	43,850	20.	52,620	20.	63,140
Winchester	1,333	33.1	1,801	7.55	1,937	1.6	1,968	34.4	2,045	17.2	3,099	22.7	3,802	7.5	4,390	14.9	4,861	15.	5,590	15.	6,430	15.	7,390	15.	8,500	15.	9,780	15.	10,250
Woburn	3,956	37.7	5,448	15.4	6,287	11.	6,999	22.3	8,500	11.8	9,568	14.2	10,931	7.5	11,750	14.9	13,499	15.	15,520	15.	17,850	10.	19,610	10.	21,600	10.	23,700	10.	26,130
Miltoo	2,241	18.5	2,666	0.5	2,669	3.8	2,770		2,683	2.0	2,738	17.1	3,206	10.9	3,555	20.3	4,278	20.	5,140	20.	6,160	20.	7,400	15.	8,500	15.	9,780	15.	10,250
Stoughton	2,085	20.8	2,518	27.3	3,206	2.9	3,208	36.8	4,513	10.5	4,981		4,900	15.7	5,659	8.8	6,155	15.	7,070	15.	8,130	15.	9,300	15.	10,750	15.	12,370	15.	14,220
Saugus	1,552	15.2	1,788	13.2	2,024		2,006	12.0	2,247	14.7	2,578	1.8	2,625	8.8	2,855	28.6	3,673	20.	4,400	20.	5,280	20.	6,310	15.	7,290	15.	8,590	15.	9,650
Lynn	14,297	10.2	15,713	21.4	19,083	8.7	20,747	36.1	28,233	15.5	32,600	17.4	38,274	19.8	45,867	21.6	55,727	20.	66,900	20.	80,280	20.	96,330	15.	110,770	15.	127,380	15.	146,500
Nahant			270	40.7	380		313	51.7	475	61.3	766	5.5	808		637		880	10.	970	10.	1,060	10.	1,170	10.	1,290	10.	1,430	10.	1,560
Wakefield	2,407	14.6	2,768	16.3	3,207	11.6	3,244	27.5	4,135	29.4	5,349	3.7	5,547	9.2	6,060	15.2	6,982	15.	8,030	15.	9,230	10.	10,190	10.	11,170	10.	12,290	10.	13,520
Total, 10 miles radius	267,861	21.6	325,863	17.3	382,343	8.4	414,452	17.8	498,924	18.8	580,523	8.4	629,484	12.1	705,521	19.3	841,617	16.4	979,560	16.9	1,144,910	15.9	1,327,340	14.9	1,525,170	14.3	1,742,870	14.2	1,990,420



GENERAL STATISTICS.

SUDBURY AND COCHITUATE WORKS.	1890.	1891.	1892.
Daily average consumption in gallons.....	33,871,700	37,686,980	41,312,400
Daily average consumption in gallons per inhabitant	82.5	89.3	95.3
Daily average amount used through meters, gallons.....	9,034,800	10,186,400	11,225,900
Percentage of total consumption metered	26.7	27.0	27.2
Number of services.....	60,718	62,877	65,074
Number of meters and motors	4,078	4,357	4,412
Length of supply and distributing mains, in miles.....	498.7	519	536
Number of fire-hydrants in use	5,398	5,643	5,793
Yearly revenue from water-rates.....	\$1,382,422 53	* \$1,838,494 30	\$1,433,413 78
Yearly revenue from metered water	\$554,047 36	† \$606,451 00	\$649,672 31
Percentage of total revenue from metered water	40.1	33	45.3
Cost of works on Jan. 1, 1891, Feb. 1, 1892 and 1893	\$20,995,015 00	* \$21,643,526 91	\$22,243,351 56
Yearly expense of maintenance	\$381,147 10	* \$398,755 92	\$350,743 68
MYSTIC WORKS.			
Daily average consumption in gallons	8,341,400	9,055,200	9,810,800
Daily average consumption in gallons per inhabitant	70.6	74.7	78.6
Daily average amount used through meters, gallons	1,537,400	1,845,500	1,862,200
Percentage of total consumption metered	18.5	20.4	19
Number of services	19,520	20,566	21,588
Number of meters and motors	414	427	550
Length of supply and distributing mains, in miles	152.3	158	160
Number of fire-hydrants in use.....	1,073	1,116	1,223
Yearly revenue from water-rates	\$332,634 02	* \$406,784 26	\$394,008 75
Yearly revenue from metered water.....	\$89,526 42	† \$102,719 26	\$105,685 56
Percentage of total revenue from metered water	26.9	25.2	26.8
Cost of works on Jan. 1, 1891, and Feb. 1, 1892 and 1893....	\$1,708,781 59	\$1,710,943 70	\$1,713,227 00
Yearly expense of maintenance	\$144,184 44	* \$174,421 92	\$117,922 20

* Thirteen months.

† Twelve months.

EARNINGS AND EXPENDITURES.

The total receipts of the Cochituate Water-Works, from all sources, for the year ending January 31, 1893, were as follows, viz. :

Balance of revenue from 1892-93		\$60,877 61
Income from sales of water	\$1,433,413 78	
Income from shutting off and letting on water, and fees	2,706 75	
Elevator, fire and service pipes, sale of old materials, etc.	21,815 84	
		1,457,936 37
		\$1,518,813 98

The total expenditures of the Cochituate Water-Works from revenue, for the year ending January 31, 1893, were as follows, viz. :

Current expenses, viz. :		
Water-Supply Department	\$350,743 68	
Less stock used purchased in previous years	2,519 23	
	\$348,224 45	
Water-Income Department	44,537 76	
	\$392,762 21	
Interest on funded debt	810,981 63	
Sinking-fund requirement, 1891-92	240,435 00	
Refunded water-rates	963 05	
Extension of mains, etc.	57,851 63	
		1,502,993 52
Balance to 1893-94		\$15,820 46

The total receipts of the Mystic Water-Works, from all sources, for the year ending January 31, 1893, were as follows, viz. :

Income from sales of water	\$394,008 75
Income from shutting off and letting on water, and fees, ...	756 25
Service-pipes, repairs, etc.	1,027 47
	\$395,792 47

The total expenditures of the Mystic Water-Works from revenue, for the year ending January 31, 1893, were as follows, viz. :

Current expenses, viz. :		
Water-Supply Department	\$118,949 83	
Water-Income Department	10,404 66	
	\$129,354 49	
Interest on funded debt	19,257 50	
Refunded water-rates	128 19	
Amount paid Chelsea, Somerville, and Everett, under contract	137,621 36	
City Treasurer, amount advanced to meet deficit of 1891-92	29,856 63	
Mystic Water Sinking-fund	50,000 00	
Extension of mains, etc., Cochituate Department	29,574 30	
		<u>\$395,792 47</u>

MAINTENANCE ACCOUNTS, COCHITUATE WATER-
WORKS.

(FROM REVENUE.)

FEBRUARY DRAFT, 1892, TO FEBRUARY DRAFT, 1893.

Boston Water Board:

Salaries of two Commissioners, Chief Clerk and Secretary, Executive Clerk, Purchasing Agent, Asst. Clerk and Messenger, and Special Agent .	\$15,566 50	
Travelling expenses	2,164 08	
Printing and stationery	676 51	
Advertising, postage, and miscellaneous,	1,044 35	
		\$19,451 44

Eastern Division:

Salaries of Superintendents, Clerks, and Foremen	\$16,146 81	
Travelling expenses and transportation of men	1,250 20	
Printing and stationery	822 66	
Miscellaneous	506 64	
		18,726 31

Western Division:

Salaries of Superintendent, Assistant Superintendent, and Clerks	\$24,373 73	
Travelling expenses	1,980 39	
Printing and stationery	376 22	
Miscellaneous	399 41	
		27,129 75
Engineering	2,198 76	
New meters, and setting	8,015 28	
Meters, repairing	19,532 62	
Machine-shop, Albany street	8,179 69	
Telephones	1,436 23	
Cochituate Aqueduct	2,197 24	
Sudbury Aqueduct	11,858 26	
Main pipe relaying (including stock and labor) .	9,241 73	
“ repairing “ “ “ “ .	7,830 73	
Hydrants “ “ “ “ “ .	22,914 20	
Stopcocks “ “ “ “ “ .	5,415 19	
Hydrant and stopcock boxes, and repairing (including stock and labor)	3,800 03	
Tools and repairing (including stock and labor) .	8,020 63	
Streets “ “ “ “ “ .	7,565 07	
Fountains “ “ “ “ “ .	3,521 89	
Stables “ “ “ “ “ .	26,042 12	
Waste-detection “ “ “ “ “ .	20,847 25	

Carried forward,

\$233,924 42

<i>Brought forward,</i>	\$233,924 42
Basins, Framingham and Ashland (including stock and labor)	10,933 89
Service-pipe repairing (including stock and labor)	21,782 40
Protection of Sudbury and Cochituate supply	1,374 02
High service, Chestnut hill (including fuel, salaries, repairs, etc.)	22,676 06
High service, East Boston (including fuel, salaries, repairs, etc.)	3,005 99
High service, West Roxbury (including fuel, salaries, repairs, etc.)	3,038 60
Albany-street yard	6,497 74
Chestnut-hill Reservoir (including stable, care of grounds, etc.)	15,470 69
Parker-hill reservoir	1,689 44
Brookline Reservoir	1,186 62
East Boston and South Boston Reservoirs	723 22
Fisher-hill Reservoir	1,472 54
Lake Cochituate	3,334 50
Chestnut-hill driveway	12,026 06
Taxes	1,389 56
Damages	1,861 90
Analyses of water, etc.	280 00
Merchandise sold (pipes and castings, in cases of emergency)	100 77
Filtration	6,584 88
Biological Laboratory	1,390 38
	<u>\$350,743 68</u>

MAINTENANCE ACCOUNTS, MYSTIC WATER-WORKS.

(FROM REVENUE.)

FEBRUARY DRAFT, 1892, TO FEBRUARY DRAFT, 1893.

Boston Water Board:

Salaries of one Commissioner and one		
Assistant Clerk	\$5,091	67
Printing and stationery	40	10
Advertising and postage	32	25
Travelling expenses and miscellaneous,	169	10
		\$5,333 12

Superintendent's Department:

Salaries of Superintendent, Assistant		
Superintendent, and Clerk	\$5,486	82
Printing and stationery	84	69
Travelling expenses	454	45
Miscellaneous	78	69
		6,104 65
Engineer's Department		1,815 00
Meters, setting and repairing		2,164 40
Off and on water (labor)		3,290 09
Main-pipe laying (including stock and labor),		2,283 30
" relaying " " "		1,759 77
" repairing " " "		821 46
Service-pipe laying " " "		1,467 66
" repairing " " "		2,040 63
Hydrants and gates, repairing (including stock and		
labor		2,082 08
Streets, repairing (including stock and labor)		455 11
Lake		10,246 67
Conduit		1,645 88
New meters and setting		2,000 54
Stables		5,267 05
Reservoir		4,921 06
Pumping service (salaries, wages, fuel, repairs, etc.),		26,212 62
Repair-shop		2,336 09
Fountains		670 89
Tools and repairing		287 03
Mystic Sewer (repairs, and pumping and treatment		
of sewage)		21,853 75
Waste-Detection Service		7,126 35
Protection of water sources (including salaries of		
three Special Agents on Pollution)		6,511 21
Analyses of water		90 00
Filtration		1,082 69
Merchandise sold		231 77
Taxes		104 63
		\$120,205 50

DETAILED EXPENDITURES UNDER THE SEVERAL APPROPRIATIONS.

FEBRUARY DRAFT, 1892, TO FEBRUARY DRAFT, 1893.

Extension of Mains, etc. (from Loans and Surplus Revenue).

Labor	\$90,383 20
Teaming	5,188 50
Blasting	9,939 09
Water-pipes, contracts	72,463 82
Stock	40,504 55
Miscellaneous	3,636 48
	¹ \$222,115 64

Additional Supply of Water (from Loans).

(Account of Basin No. 6, Whitehall pond, Cedar swamp, and Surveys and Borings for Basin No. 5.)

Salaries and labor	\$46,761 19
Materials	18,202 92
Contract, filling on Dam No. 6 (on account)	23,434 26
Contract, stripping Section A, Basin 6, balance (total, \$25,407.72)	10,697 09
Contract, stripping Section B, Basin 6, balance (total, \$23,276.24)	14,351 15
Contract, stripping Section C, Basin 6, balance (total, \$36,868.80)	23,700 94
Contract, stripping Section D, Basin 6 (on account)	23,345 57
Contract, stripping Section E, Basin 6 (on account)	39,672 79
Contract, 2 sluice gates, at Basin 6	1,603 81
Contract, upper section, wasteway, Dam 6	22,392 13
City of Marlboro', balance of contract for a sewerage system to protect city water supply (total contract, \$62,000)	20,666 67
Town of Westboro', on account of contract for a system of sewage disposal for the protection of the Boston water supply	13,333 33
Engineering and supplies	20,389 55
Land damages	17,537 56
Teaming	10,067 85
Freights and express	784 58
Travelling expenses	804 02
Printing, stationery, and advertising	379 23
Miscellaneous	5,719 89
	\$313,844 53

¹ \$122.93 of this amount not used, and carried into the Stock account.

High Service (from Loans).

(Account of High-service Pumping-engine No. 3 for Chestnut hill).

Contract for engine (on account)	.	.	\$12,277 82
Design, drawings, royalties, and inspection	.	.	3,490 01
Steel forgings (on account)	.	.	6,340 44
Beam castings	.	.	879 27
Miscellaneous, bolts, nuts, etc.	.	.	1,362 36
Stock and labor on foundations (day-work)	.	.	8,416 56
Contract-work, foundations (on account)	.	.	891 31
			<u>\$63,657 77</u>

COST OF CONSTRUCTION, AND CONDITION OF THE WATER DEBTS.

Cost of construction of Cochituate Works
to Feb. 1, 1892 \$21,643,526 91

Expended from Feb. 1, 1892, to Feb. 1,
1893, as follows, viz.:

Additional Supply of Water .	\$313,844 53
Extension of Mains, etc. .	221,992 71
High Service	63,987 41
	599,824 65

Cost of construction of Cochituate Water- Works to Feb. 1, 1893	\$22,243,351 56
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The outstanding Cochituate Water Loans,
Feb. 1, 1892, were \$16,423,773 98

Issued during the year 1892-93, as follows:

Appropriation,	{	Additional Supply of Water,	
	{	4% Loans,	\$235,000 00
“	{	Extension of Mains, etc., 4%	
	{	Loans .	100,000 00
			335,000 00

Total Cochituate Debt, Feb. 1, 1893 .	\$16,758,773 98
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Cochituate Water Sinking-Fund, Feb. 1, 1892	\$6,471,545 34
Cochituate Water Sinking-Fund, Feb. 1, 1893	7,019,058 38

Net Cochituate Water Debt, Feb. 1, 1892 .	\$9,952,228 64
“ “ “ “ Feb. 1, 1893 .	9,739,715 60

Cost of construction of Mystic Works to Feb. 1, 1892	\$1,710,943 70
Cost of construction of Mystic Works to Feb. 1, 1893	<u>1,713,227 00</u>
The outstanding Mystic Water Loans, Feb. 1, 1892, were	\$482,000 00
Paid during year 1892-93	<u>42,000 00</u>
Total Mystic Debt, Feb. 1, 1893	<u>\$440,000 00</u>
Mystic Water Sinking-Fund, Feb. 1, 1892,	\$550,208 70
“ “ “ Feb. 1, 1893,	<u>579,254 01</u>

TOTAL MONEY EXPENDITURES, COCHITUATE WATER-
WORKS, FROM FEBRUARY 1, 1892, TO FEBRUARY 1,
1893.

Stock	\$115,813 99
Labor	296,062 70
Salaries	63,945 85
Travelling expenses	10,919 30
Printing	1,773 37
Stationery	610 86
Advertising	560 61
Postage	233 96
Freights and express	1,539 97
Rents	3,366 17
Gas	235 53
Teaming	17,467 98
Repairs	14,528 60
Land damages, etc.	17,537 56
Taxes	1,389 56
Miscellaneous	7,365 47
Inspection of pipes	2,072 09
Blasting	10,527 48
Water-pipe contracts	74,733 48
Coal and wood	3,609 76
Pumping Service, salaries	10,150 40
“ “ fuel	6,593 29
“ “ repairs	192 51
“ “ oils, etc.	574 95
“ “ small supplies	352 48
Miscellaneous contracts	259,355 85
Engineering	20,338 76
Engineering supplies	305 55
Hay and grain	5,684 31
	<u>\$947,842 39</u>

TOTAL MONEY EXPENDITURES, MYSTIC WATER-
WORKS, FROM FEBRUARY 1, 1892, TO FEBRUARY 1,
1893.

Stock	\$7,527 19
Labor	42,238 41
Salaries	24,635 72
Advertising	32 25
Printing	116 83
Stationery	96 25
Taxes	104 63
Rents	25 00
Gas	53 50
Postage	30 00
Travelling expenses	2,808 80
Coal and wood	251 73
Freights and express	256 55
Teaming	11 00
Hay and grain	901 05
Repairs	1,821 19
Miscellaneous	281 16
Telephones	443 98
Pumping Service, salaries	9,613 93
“ “ fuel	11,830 68
“ “ repairs	511 09
“ “ oils, etc.	744 51
“ “ small supplies	348 44
Engineering	27 50

Mystic Sewerage Station, viz. :

Salaries and wages	8,616 82
Fuel	818 22
Chemicals	2,941 94
Repairs	724 47
Small supplies	1,136 99

\$118,949 83

STATEMENT OF STOCK ACCOUNTS.

			Increase.	Decrease.
Cochituate Water-Works, viz. :				
Stock on hand, February 1, 1892	.	\$25,080 37		
“ “ “ February 1, 1893	.	22,561 14		
Decrease during year	. . .	<u>\$2,519 23</u>		\$2,519 23
Mystic Water-Works, viz. :				
Stock on hand, February 1, 1892	.	\$5,205 85		
“ “ “ February 1, 1893	.	3,950 18		
Decrease during year	. . .	<u>\$1,255 67</u>		1,255 67
Extension of Mains, etc., viz. :				
Stock on hand, February 1, 1892	.	\$97,344 62		
“ “ “ February 1, 1893	.	97,467 55		
Increase during year	. . .	<u>\$122 93</u>	\$122 93	
High Service, viz. :				
Stock on hand, February 1, 1892	.	\$4,643 39		
“ “ “ February 1, 1893	.	4,313 75		
Decrease during year	. . .	<u>\$329 64</u>		329 64
			<u>\$122 93</u>	<u>\$4,104 54</u>
Total decrease in stock during year 1892-93				<u>\$3,981 61</u>

The outstanding loans on account of Additional Supply of Water on February 1, 1893, are as follows :

6 per cent. Loans . . .	\$644,000	{	\$100,000	Due July, 1902
			492,000	Due April, 1903
			8,000	Due Jan., 1904
			44,000	Due July, 1905
5 per cent. Gold Loans . . .	3,452,000	{	1,000,000	Due Oct., 1905
			452,000	Due April, 1906
			2,000,000	Due Oct., 1906
5 per cent. Cur. Loan . . .	12,000			Due April, 1908
4½ per cent. Loan . . .	268,000			Due Oct., 1909
3½ per cent. Loans . . .	180,000	{	35,000	Due April, 1917
			145,000	Due Oct., 1919
			588,000	Due April, 1908
			82,000	Due July, 1909
			324,000	Due April, 1912
			336,000	Due Oct., 1913
			209,000	Due Jan., 1914
			18,500	Due April, 1914
4 per cent. Loans . . .	2,397,500	{	16,000	Due Oct., 1914
			1,500	Due April, 1915
			100,000	Due April, 1916
			50,000	Due Oct., 1916
			300,000	Due Oct., 1919
			134,000	Due Oct., 1920
			162,500	Due Oct., 1921
			76,000	Due Oct., 1922
			<u>\$6,953,500</u>	

The outstanding Mystic Water Loans at this date, February 1, 1893, are as follows :

6 per cent. Currency Loans,	\$39,000			Due July 1, 1893
5 per cent. Currency Loans,	108,000	{	\$6,000	Due Oct. 1, 1893
			102,000	Due April 1, 1894
4 per cent. Loans	18,000	{	3,000	Due April 1, 1898
			15,000	Due Oct. 1, 1913
3½ per cent. Loans	110,000	{	60,000	Due Oct. 1, 1896
			50,000	Due Oct. 1, 1897
3½ per cent. (Mystic Sewer) Loans	130,000			Due April 1, 1916
3¼ per cent. Loans	35,000			Due April 1, 1896
			<u>\$440,000</u>	

The following statement shows the appropriations by the City Council for an additional supply of water, and the amount of expenditures to February 1, 1893:

APPROPRIATIONS.

Oct. 21, 1871. — Transfer from Reserved Fund	\$10,000 00	
Apr. 12, 1872. — Order for Treasurer to borrow	100,000 00	
Apr. 11, 1873. — Order for Treasurer to borrow	500,000 00	
Feb. 26, 1875. — Order for Treasurer to borrow	1,500,000 00	
Oct. 1, 1875. — Premium on \$1,000,000 bond, under order of February 26, 1875	83,700 00	
Apr. 1, 1876. — Premium on \$452,000 bonds, under order of February 26, 1875	47,786 80	
July 1, 1876. — Order for Treasurer to borrow	2,000,000 00	
Oct. 1, 1876. — Premium on \$2,000,000 bonds, under order of July 1, 1876	221,400 00	
Apr. 20, 1878. — Order for Treasurer to borrow	600,000 00	
Apr. 11, 1879. — Order for Treasurer to borrow	350,000 00	
Aug. 17, 1881. — Order for Treasurer to borrow	324,000 00	
June 2, 1883. — Order for Treasurer to borrow	621,000 00	
Oct. 14, 1884. — Order for Treasurer to borrow	150,000 00	
May 28, 1887. — Order for Treasurer to borrow	35,000 00	
Nov. 13, 1889. — Order for Treasurer to borrow	1,045,000 00	
Oct. 24, 1891. — Forfeiture of contract bond	2,500 00	
Dec. 24, 1892. — Transfer	20,000 00	
	\$7,610,386 80	
Less transfers June 4, 1888, and January 3, 1890	12,946 48	
		\$7,597,440 32

EXPENDED.

1871-72	\$2,302 81	
1872-73	61,278 83	
1873-74 including \$20,897.50 discount on bonds sold, January, 1874	114,102 77	
Carried forward,	\$177,684 41	\$7,597,440 32

<i>Brought forward,</i>							\$177,684 41	\$7,597,440 32
1874-75	.	.	.	.	.	.	224,956 68	
1875-76	.	.	.	.	.	.	783,613 49	
1876-77	.	.	.	.	.	.	1,924,060 24	
1877-78	.	.	.	.	.	.	1,257,715 26	
1878-79	.	.	.	.	.	.	635,658 08	
1879-80	.	.	.	.	.	.	213,350 97	
1880-81	.	.	.	.	.	.	97,406 78	
1881-82	.	.	.	.	.	.	35,677 98	
1882-83	.	.	.	.	.	.	167,621 43	
1883-84	.	.	.	.	.	.	423,625 79	
1884-85	.	.	.	.	.	.	276,292 13	
1885-86	.	.	.	.	.	.	139,187 68	
1886-87	.	.	.	.	.	.	128,109 32	
1887-88	.	.	.	.	.	.	30,332 77	
1888-89	.	.	.	.	.	.	2,398 90	
1889-90	.	.	.	.	.	.	18,518 01	
1890-91	.	.	.	.	.	.	233,710 59	
1891-92	.	.	.	.	.	.	281,271 82	
1892-93	.	.	.	.	.	.	313,844 53	
								7,365,036 86
Balance unexpended February 1, 1898.							.	<u><u>¹\$232,403 46</u></u>

¹ \$227,500 unnegotiated on this date.

Contracts Made and Pending during Year commencing February 1, 1892, and ending January 31, 1893.

Contracts marked with star () are completed. Amounts marked with (+) are for extra work.*

DATE.	CONTRACTORS.	WORK.	AMOUNT.	PAID ON CONTRACT.		
				Previous Years.	Year 1892.	Total.
1890.						
Apr. 26,	D. Henry Cram	Rental of derricks for use at Basin No. 6	\$200 each 1st year, \$100 each after,	\$2,000 00	\$400 00	
*July 15,	Town of Marlboro'	{ Sewerage system for the removal of the sewage } of said town from the Sudbury-river water-shed, {	\$62,000		{ 41,333 33 } { 20,666 67 }	{ \$62,000 00 }
1891.						
*Jan. 1,	R. D. Wood & Co.	Water-pipes and special castings	\$27.95 per ton of 2,240 lbs.	87,463 94	16,289 52	103,753 46
*Mar. 6,	Pierce F. Lonergan	Tanning pipes, etc., for year ending March 15, 1892,	{ \$0.74 per ton, 2½ miles } 1.35 " " over 2½ miles }	3,617 67	787 83	4,405 50
* " 9,	Osgood & Hart	Iron and service-box castings	2 cents per lb.	10,274 25	1,868 05	12,142 30
* " 9,	William Curley	Brass castings	{ Composition, No. 1, 18½c. per lb. } " " 2, 16½c. " " } " " 3, 15c. " " }	3,789 08	2,027 47	5,816 55
May 26,	Town of Westboro'	{ System of sewage disposal, to remove sewage of } town outside of Sudbury-river water-shed . . }	\$20,000		13,333 33	
*July 13,	August Saucier	Excavation, Section B, Basin No. 6	26 cents per cubic yard	8,925 09	14,351 15	23,276 24
" 14,	Joseph Gennaro	Excavation, Section A, Basin No. 6	30½ cents per cubic yard	14,710 63	10,697 09	25,407 72
" 15,	Moulton, O'Mahoney, & Trumbull	Excavation, Section C, Basin No. 6	40 cents per cubic yard	13,167 86	23,700 94	36,868 80
" 15,	Moulton, O'Mahoney, & Trumbull	Excavation, Section D, Basin No. 6	62 cents per cubic yard	21,878 93	23,345 57	

Oct.	5,	Barnabas Clarke	{ Filling on Dam No. 6, Ashland (for completion of } { Charles H. Hale's contract) }	{ Same as under Hale's contract, of } { Jan. 20, 1891, and \$2,500 addi- } { tional on completion of work }	1,932 06	23,434 26
* "	12,	F. L. Whitcomb	Stable on Gibson street, Dorchester	\$2,600		{ 2,600 00 } { + 6 00 }
* Nov.	2,	Ingalls & Kendick	{ Hot-water heating-apparatus, office, South Fran- } { ingham, Mass. }	\$850		{ 850 00 } { + 76 50 }
1892.	Jan. 13,	John Berry & Co.	Excavation, Section E, Basin No. 6	(\$47,786, estimated)		39,672 79
* Feb.	4,	George R. Cavanagh	Raising office building, South Framingham, Mass.	\$225		{ 225 00 } { + 25 00 }
"	25,	Radford Pipe and Foundry Company	{ 2,020 tons water-pipes } { 150 tons specials }	\$25.40 per ton 2,240 lbs. for pipes } 50.40 " " " " for specials }		57,991 14
Mar.	14,	Pierce F. Lonergan	Tanning pipes, etc., for year ending March 15, 1893, ...	{ \$0.69 per ton 2 1/2 miles } { 1.49 " " over 2 1/2 miles }		2,418 83
"	15,	Stephen Anderson	Brass castings	{ Composition, No. 1, 18c. per lb. } { " " 2, 15 1/2c. " " } { " " 3, 14 1/2c. " " }		3,813 92
"	15,	Osgood & Hart	Iron and service-box castings	1 19-20 cents per lb.		9,415 56
* "	16,	Martin F. Kelley	Blasting, Bellevue street, Dorchester	\$3.98 per cubic yard		71 64
* "	18,	American Bolt Company	Wrought-iron bolts and nuts for 3d pumping-engine, ...	\$470		470 00
* "	26,	R. D. Wood & Co.	{ 6 tons 6-in. pipe, with flexible joints } { 12 tons special castings }	{ \$37.75 per ton for pipe, est'm'd } 55.00 " " specials, } \$886.50 }		896 59
* "	30,	Martin F. Kelley	Blasting, Paul Gore street, West Roxbury	\$3.45 per cubic yard		119 37
* Apr.	12,	O. D. Witherell	{ 600 tons Cumberland coal, Chestnut-hill Pumping- } { station }	\$4.55 per ton (2,240 lbs.) in bins		2,742 26
* "	12,	John B. Gunning	Blasting, Cranston street, West Roxbury	\$3.90 per cubic yard		61 62
"	15,	A. P. Eldridge	Quarrying and delivering stone, Basin No. 6	\$2.50 per cubic yard		375 00
* "	22,	Martin F. Kelley	Blasting, Fremont street, Dorchester	\$4.40 per cubic yard		104 72

Contracts Made and Pending during Year. — Continued.

DATE.	CONTRACTORS.	WORK.	AMOUNT.	PAID ON CONTRACT.		
				Previous Years.	Year 1892.	Total.
1892.						
* April 26,	Wm. L. O'Connell . . .	Blasting, Burney street, Roxbury	\$3.39 per cubic yard			No rock found.
* " 27,	D. Henry Cram	Upper Section, Waste-way, Basin No. 6	(\$22,844.75 estimated)			\$22,392 13
* " 27,	{ Storage Battery Supply } Co.	{ Storage battery plant, Chestnut-hill Pumping- station	{ \$424.20	{	{	{ 424 20
* " 27,	T. W. Gleeson	{ Rearranging wiring, etc., for electric light, Chest- nut-hill Pumping station	{ \$112	{	{	{ 112 00
* " 30,	Wm. L. O'Connell . . .	Blasting, Riehlview street, Dorchester	\$3.95 per cubic yard			82 16
* May 9,	Martin F. Kelley	Blasting, Ingleside street, Roxbury	\$2.98 per cubic yard			39 34
" 11,	John A. Bradford & Co. .	{ 2,600 tons Cumberland coal for Mystic Pumping- station, delivered on cars at Mystic wharf . . . }	{ \$3.54 per ton of 2,240 lbs.	{	{ \$8,637 60	
* " 12,	John Cavanagh & Co. . .	Laying 6-inch pipe to Thompson's island	\$3,852			3,043 23
* " 12,	Martin F. Kelley	Blasting, Centre street, Roxbury	\$4.84 per cubic yard			48 40
* " 18,	J. C. Coleman	Blasting, Surrey street, Brighton	\$5.25 per cubic yard			311 85
* " 20,	Martin F. Kelley	Blasting, Rand place, Roxbury	\$4.25 per cubic yard			39 53
* " 21,	P. J. McNulty	Blasting, Wenham street, West Roxbury	\$3.50 per cubic yard			20 90
* " 23,	Martin F. Kelley	Blasting, Chiswick road, Brighton	\$3.49 per cubic yard			160 54
* June 3,	J. C. Coleman	Blasting, Bowdoin square, Dorchester	\$4.90 per cubic yard			68 60
* " 8,	Thomas Burke	Blasting, Hygeia road, Roxbury	\$3.48 per cubic yard			101 96

* "	9,	J. C. Coleman	Blasting, Evelyn street, Dorchester	\$9.75 per cubic yard	123 83
* "	14,	John Cavanagh & Co.	{ Furnishing and laying 4 inch iron and the service } pipes at Thompson's Island	30 cents linear foot for iron . . . 17 cents linear foot for lead . . .	154 91
* "	15,	Martin F. Kelley	Blasting, Washington street, West Roxbury	\$4.00 per cubic yard	404 80
* "	18,	James McLaughlin & Son,	Blasting, Huntoon street, Dorchester	\$5.75 per cubic yard	53 48
* "	23,	Atlantic Works	Two 48-inch sluice-gates for Dam 6	\$1,750	{ \$146 10 } Work done by the city. { 1,603 81 }
* "	24,	West Point Foundry Co.	Gun-iron castings for Pumping-engine No. 3	{ 34.10 cents per lb. and } \$160.00 for patterns	1,603 81
"	8,	N. F. Palmer, Jr., & Co.	High-service Pumping-engine No. 3	{ \$124,000.00 } 3,500.00 } Loss on account Modification.	879 27
* July	8,	Martin F. Kelley	Blasting, Granville street, West Roxbury	\$5.20 per cubic yard	265 72
* "	19,	Martin F. Kelley	Blasting, Dorchester avenue, Dorchester	\$7.00 per cubic yard	407 60
* "	22,	Thomas Burke	Blasting, Holborn park, Roxbury	\$3.15 per cubic yard	30 24
* Aug.	8,	J. C. Coleman	Blasting, Juniper street	\$3.43 per cubic yard	174 93
* "	22,	Thomas Prosser & Son	{ Steel forgings for high-service Pumping engine } No. 3	28 cents per lb., f.o.b. cars	6,340 44
Sept.	1,	O. D. Witherell	{ 800 tons Cumberland coal, Chestnut-hill Pumping- } station	\$4.66 per ton, in bins	3,755 03
* "	1,	Martin F. Kelley	Blasting, Broadway, South Boston	\$3.50 per cubic yard	96 95
"	2,	Donovan & Brock	Foundations for high-service Pumping-engine No. 3,	{ \$4.90 per cu. yd. brick masonry } 65.00 per cu. yd. cap-stone, etc.	891 31
* " 12, 16,		John Cavanagh & Co.	Laying pipes on Long and Gallop's islands		1,392 39
* "	12,	Thomas Burke	Blasting, Brunswick street, Roxbury	\$3.18 per cubic yard	159 32

Contracts Made and Pending during Year. — *Concluded.*

DATE.	CONTRACTORS.	WORK.	AMOUNT.	PAID ON CONTRACT.		
				Previous Years.	Year 1892.	Total.
1892.						
Sept. 12,	Martin F. Kelley	Blasting, Lamartine terrace, West Roxbury	\$4.20 per cubic yard			\$47 88
" 13,	George W. Townsend	{ Laying 3-inch wrought-iron submerged pipe from Long to Gallop's island }	35 cents per linear foot			{ Paid by Board of Health. \$229 90
" 17,	Thomas Burke	Blasting, Mattapan street, Dorchester	\$4.13 per cubic yard			87 34
" 19,	Martin F. Kelley	Blasting, Franklin park, near Morton street	\$3.97 per cubic yard			53 30
" 28,	Martin F. Kelley	Blasting, Percival avenue, Dorchester	\$6.50 per cubic yard			71 55
" 28,	Martin F. Kelley	Blasting, Newburg street, West Roxbury	\$6.75 per cubic yard			
" 29,	Lamprey Boiler Furnace Month Protector Co.	{ Attachment to boilers at Pumping-stations, 6 mos. trial free of expense to city }	\$90 per boiler, if iron, } 105 per boiler, if brass, } accepted.			135 20
" 30,	J. C. Coleman	Blasting, Paul Gore street, West Roxbury	\$4.00 per cubic yard			78 00
*Oct. 5,	Martin F. Kelley	Blasting, Puritan avenue, Dorchester	\$5.20 per cubic yard			129 12
" 13,	Thomas Burke	Blasting, Intervale street, Roxbury	\$3.38 per cubic yard			81 50
" 28,	Wm. L. O'Connell	Blasting, Nelson street, Dorchester	\$5.00 per cubic yard			68 54
" 29,	Martin F. Kelley	Blasting, Berwick road, Brighton	\$4.60 per cubic yard			208 35
" 29,	Martin F. Kelley	Blasting, Sol Kirk road, Brighton	\$4.50 per cubic yard			52 29
*Nov. 1,	Thomas Burke	Blasting, Brookford street, Dorchester	\$3.15 per cubic yard			554 52
" 2,	Wm. L. O'Connell	Blasting, Rockville street, Dorchester	\$4.49 per cubic yard			113 82
" 14,	Thomas Burke	Blasting, Greenhays street, Dorchester	\$4.20 per cubic yard			

* " 30,	Martin F. Kelley	Blasting, Edgewood park, Roxbury	\$5.00 per cubic yard		65 00
* " 30,	J. C. Coleman	Blasting, Mountain avenue, Dorchester	\$4.00 per cubic yard		232 80
*Dec. 1,	Wm. L. O'Connell	Blasting, Doody's court, Dorchester	\$6.00 per cubic yard		60 00
" 3,	J. C. Coleman	Blasting, Lanriat avenue, Dorchester	\$3.99 per cubic yard		197 11
1893.					
Jan. 10,	Wellman Iron and Steel Co.	Steel plates for high-service Pumping-engine No. 3.	4½ cents per lb., delivered.		
" 25,	R. D. Wood & Co.	10 tons 4-inch B pipe, 600 tons 6-inch B pipe . . . } 400 tons 8-inch B pipe, 100 tons 16-inch A pipe . . } 399 tons 24 inch A pipe, 1,100 tons 36-inch A pipe 100 tons special castings	\$25.94 per ton 25.21 per ton 25.60 per ton		
" 28,	N. F. Palmer, Jr., & Co.	Covering with brass 3 pump-rods for Pumping-engine No. 3	\$200.00.		

REPORT OF THE SUPERINTENDENT OF THE EASTERN DIVISION.

OFFICE OF SUPERINTENDENT OF EASTERN DIVISION,
710 ALBANY STREET, BOSTON, February 1, 1893.

ROBERT GRANT, Esq., *Chairman Boston Water Board:*

DEAR SIR: I herewith respectfully submit the annual report of the Eastern Division for the year ending January 31, 1893.

DISTRIBUTION OF MAINS.

Nearly eighteen miles of pipe mains have been laid during the year, and 4,270 feet of pipe have been abandoned, making a net increase in the distribution system of 17.08 miles, and a total length of 535.87 miles now connected with the works.

The work of extending the 30-inch main through Chester square and Swett street, connecting it with the 20-inch main on Dorchester avenue, was completed early in the spring. This pipe is connected to the 36-inch and the 30-inch mains on Tremont street.

A 6-inch pipe main was laid from Squantum to Thompson's island, a distance of 6,760 feet, and there were 155 feet of 4-inch pipe laid for service-pipe on the island. There were also 2,874 feet of 6-inch pipe laid on Long island, and 991 feet of 6-inch pipe laid on Gallop's island. All of this pipe was laid by John Cavanagh & Co.

The high service was extended as follows: Mather street to Nixon street; Blue Hill avenue, between Tileston avenue and Fremont street; Fremont street, between Blue Hill avenue and River street; Norfolk street, from Blue Hill avenue to Delhi street, Dorchester.

The high service was also extended in State street, between Merchants row and Broad street; Merchants row, between State street and Chatham street; Chatham street, between Merchants row and Chatham row; and Devonshire street, from Franklin street, 251 feet towards Milk street, city; W. Broadway, between Dorchester and F streets, South Boston; Johnson street and Buckley avenue, Roxbury, were also changed to high service.

The 40-inch pipe was raised and relaid across the new bridge on Brookline avenue, between Francis street and Aspinwall avenue.

Two hundred and ninety-four petitions for extensions of mains have been received, and 234, including 15 of 1891, have been granted and mains extended.

STOPCOCKS.

During the year there were 245 stopcocks established and 26 abandoned, making a net increase of 219, and a total of 5,910 now in service.

Two 36-inch stopcocks were established to shorten the line in case of emergency: one at the corner of Tremont and Francis streets, and the other on the 40-inch main at Brookline avenue and Francis street.

HYDRANTS.

Two hundred and three hydrants have been established and 55 abandoned, making a net increase of 148, and a total of 5,853 hydrants now connected with the system. Twenty of the old pattern Boston hydrants have been replaced by hydrants of the Post and Lowry pattern.

The Post hydrant, with independent shut-off or valve for each steamer connection, is almost perfected; four of them now in service have proven satisfactory, and I expect to have a number of them ready to be put in when we commence laying pipe in the spring.

SERVICE-PIPES.

Two thousand four hundred and forty-seven service-pipes have been laid, with an aggregate length of 59,807 feet, and 250 have been abandoned, making an increase of 2,197 pipes during the year. I recommend that a rule be made to govern the number of pipes a building should have.

HIGH-SERVICE WORKS.

Chestnut Hill Station. — The engines, boilers, and other property at this station are in good condition. Early in the year the addition for the electric engine was completed. An Armington & Syms 6½ inch × 12 inch engine was bought, set up, and connected to the spare dynamo. The old Payne engine was practically rebuilt, set up in the new room, and the old dynamo repaired, which gives us a duplicate electric plant.

The work on the foundation for the new engine is progressing satisfactorily.

West Roxbury Station. — The pumps and boilers at this station are in good condition.

East Boston Station. — The boilers at this station are in good order. Pumps Nos. 1 and 2 should be overhauled during the coming year, and such parts as are badly worn should be renewed. Pump No. 3 should be entirely rebuilt; and I recommend that the one of the same pattern now stored at the Albany-street yard be repaired. This would save all the delay caused by repairing No. 3.

The grounds around the Water Tower at Mt. Bellevue, West Roxbury, are in good condition, but the tower should be painted during the coming year. The one at Orient Heights, East Boston, is in good condition.

Pipe Yard and Buildings. — The machine-shop is in good condition. The asphalt on the second floor of the stable is in a bad condition, and it should be renewed during the coming summer. I would respectfully call your attention to my recommendation of last year, in regard to a two-story brick building to be erected on the north side of the yard.

District Yards. — The yards at East Boston, Dorchester, and Brighton are in good condition, but the one at West Roxbury is in poor condition, and I would again recommend that a site be obtained for a yard for this district.

Reservoirs. — The grounds around Parker Hill, East Boston, and South Boston are in good condition.

METERS.

Cochituate Division. — Two hundred and ten meters have been applied, and 137 have been discontinued, making a net increase of 73, and the total number in service 3,912.

Mystic Division. — Forty-nine meters have been applied and twenty have been discontinued, making a net increase of 29, and the total number in service 435.

WASTE DETECTION.

The following table shows the work done by the inspectors in this department during the past year, having inspected the entire territory supplied by the Cochituate and Mystic systems:

Premises examined	74,943
Defective fixtures	10,964
Reëxamination	9,737
Second notice to repair issued	815
Second reëxamination made	858
Wilful-waste notices issued	140
Hopper water-closets not self-closing reported	42

The defective fixtures may be divided into the following classes :

Ball-cocks	6,031
Faucets, — sink, bowl, and bath-tub	3,852
Water-closets	1,739
Services burst inside building	751
Services burst outside building	89
Wilful waste	140

DEACON METER SYSTEM.

There are now in use 81 meters, — 74 on the Cochituate system and 7 on the Mystic system.

The consolidated results of the readings of the various sections are shown in the following table, in which is given the final reading of 1891 and the first and last reading of 1892 :

	Population.	1891.		1892.			
		2D READING.		1ST READING.		2D READING.	
		Daily consumption.	Night consumption.	Daily consumption.	Night consumption.	Daily consumption.	Night consumption.
		Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Cochituate	337,900	50.6	31.3	52.8	32.9	54.2	35.0
Mystic	42,600	40.6	26.2	39.7	23.3	43.0	27.3

In connection with the meters, out of 3,746 night examinations by means of the church and sidewalk shut-offs, there were 1,454 detections of defective fixtures, and 14 of wilful waste. There were also 658 hand-hose reported for non-payment.

WATER-POSTS.

Seventy-three water-posts have been erected and four abandoned, making an increase of 69, and the total number in use 320.

FOUNTAINS.

Six drinking-fountains were established and one abandoned.

JAMAICA POND AQUEDUCT COMPANY.

The pipe system of the Jamaica Pond Aqueduct Works became a part of the Eastern division January 10, 1893.

The following tables show in detail the work performed by this division during the year :

Statement of Location, Size, and Number of Feet of Pipe laid during the Year ending January 31, 1893.

NOTE. — B. indicates Boston; S.B., South Boston; E.B., East Boston; Rox., Roxbury; Dor., Dorchester; W.R., West Roxbury; Bri., Brighton.

In what Street.	Between what Streets.	District.	Size.	Length.
Chester sq.	Washington and Tremont	B.	30	1,278
East Chester park . .	Albany and Washington	"	"	46
Swett	East Chester park and Boston	S.B. and B.	"	2,101
	Total 30-inch			<u>3,425</u>
Chester sq.	Shawmut ave. and Tremont	B.	24	84
Swett	Albany and Ellery	S.B. & Rox.	"	121
	Total 24-inch			<u>205</u>
Commonwealth ave. .	Deerfield and Sherborn	B.	16	691
Deerfield	Beacon and Commonwealth ave.	"	"	72
Dudley ave.	Bellevue ave. and Brandon	W.R.	"	132
	Total 16-inch			<u>895</u>
Berkeley	Over the B. & A. R.R. bridge	B.	12	213
Deerfield	Commonwealth ave. and Bay State road,	"	"	33
Swett	Boston and Ellery	S.B.	"	70
Byron	Saratoga and Bennington	E.B.	"	138
Prescott	Chelsea and B., L., & R. B. R.R.	"	"	57
Brookline ave.	Boylston and Bellevue	Rox.	"	326
Creighton	Day and Centre	"	"	358
Fenway	From Parker	"	"	26
Hunnehan	Washington and Harrison ave.	"	"	513
Lawn	From Hayden	"	"	118
Parker Hill ave. . . .	Hillside ave. and Parker	"	"	291
Parker	Huntington ave. and Westland ave. . .	"	"	195
Riverway	Huntington ave. and Brookline ave. . .	"	"	3,799
Swett	East Chester park and N.Y. & N.E. R.R.,	"	"	282
Westminster	Ruggles and Williams	"	"	378
Ashmont	Newhall and Neponset ave.	Dor.	"	72
Blue Hill ave.	Fremont and Tileston ave.	"	"	1,452
Blue Hill ave.	Evelyn and Morton	"	"	157
Dewey	Danube and Howard ave.	"	"	29
	Carried forward			<u>8,487</u>

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			8,487
Fremont	Norfolk and Blue Hill ave.	Dor.	12	409
Harvard	School and Kilton	"	"	375
Lauriat ave.	Lyons and Mountain ave.	"	"	485
Mountain ave.	From Lauriat ave.	"	"	590
Milton ave.	Fuller and Fairmount	"	"	183
Morton	Fuller and Codman	"	"	163
Magnolia	Quincy and Lawrence ave.	"	"	118
Nelson	Norfolk and Evans	"	"	186
Park	Dorchester ave. and Vinson	"	"	1,021
Rockville	Oakland and Blue Hill ave.	"	"	632
Savin Hill ave.	Spring and Grampian way	"	"	126
Westville	Draper and Ditson	"	"	224
Water	Walnut and Taylor	"	"	307
Brandon	Dudley ave. and Aldrich	W.R.	"	481
Beech	Cypress and Newbergh	"	"	1,058
Moss Hill road	May and Woodland road	"	"	917
Newbergh	Brandon and Berry	"	"	578
Prospect	Amherst and Linden	"	"	108
Vermont ave.	From Corey	"	"	329
Williams	Washington and Plainfield	"	"	153
Washington	Schumann and Cottage	"	"	2,042
Weld	Dwinel and Aldrich	"	"	207
Woodland ave.	Moss Hill road and Pond	"	"	458
	Total 12-inch			<u>19,637</u>
Belvidere	Dalton and Bothnia	B.	10	298
Devonshire	Franklin and Milk	"	"	251
Stanhope	Berkeley and Morgan	"	"	433
Taylor	Water and Franklin	Dor.	"	172
Brook	Berry and Hill	W.R.	"	60
	Total 10-inch			<u>1,214</u>
Albany-street yard	From Albany st.	B.	8	183
Boylston sq.	Washington and Boylston	"	"	364
Cromwell	West Chester park and Dalton	"	"	450
	<i>Carried forward</i>			997

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			997
Chatham row	State and Chatham	B.	8	153
Chatham	Merchants and Chatham row	"	"	249
Gilbert pl.	Summer and Aldine	"	"	184
Merchants row	State and Chatham	"	"	115
State	Merchants row and Broad	"	"	207
"	Washington and Devonshire	"	"	145
Stanhope	Morgan and O. C. R.R.	"	"	247
West Chester park	St. Botolph and O. C. R.R.	"	"	42
Washington	Boylston and Boylston square	"	"	16
Jackson	Boston and Dorchester ave.	S.B.	"	174
Gladstone	Selma and Park	E.B.	"	108
Brunswick	Warren and Blue Hill ave.	Rox.	"	488
Elmwood	Linden park and King	"	"	413
Hampshire	Ruggles and Vernon	"	"	475
Kingsbury	Granger and Bainbridge	"	"	48
Pontine	Norfolk ave. and Clifton	"	"	589
Reading	Swett and Kemble	"	"	1,128
Texas	Tremont and Elmwood	"	"	322
Argyle	Dorchester and Welles aves.	Dor.	"	299
Brookford	Danube and Howard ave.	"	"	96
Ballou	From Jones ave.	"	"	227
Bowdoin sq.	Westville and Geneva ave.	"	"	214
"	" " Dakota	"	"	280
Bernard	Harvard and Nightingale	"	"	211
Clayton	Freeport and Fenton	"	"	8
Fenton	Clayton and Fenton pl.	"	"	252
Huntoon	Medway and Butler	"	"	181
Kenwood	Washington and Seaborn	"	"	481
Mayfield	From Pleasant	"	"	436
Melville ave.	Upland and Dorchester ave.	"	"	615
N. Munroe terrace	From Neponset ave.	"	"	500
Nightingale	" Bernard	"	"	699
Puritan ave.	" Richfield	"	"	87
Rosemont terrace	" Rosemont	"	"	60
	<i>Carried forward</i>			10,746

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			10,746
W. Park	Washington and Herbert	Dor.	8	318
Aldrich	Brandon and Cornell	W. R.	"	654
Braudon	Linden and Bellevue ave.	"	"	804
Boyleston	Centre and Burr	"	"	32
Billings	From Centre	"	"	295
Burley	Dale and Metropolitan ave.	"	"	185
Farquhar	South and Centre	"	"	799
Granville	From Beech	"	"	407
Hemlock	Washington and Bellevue ave.	"	"	599
Lotus pl.	" " Stony Brook	"	"	326
Mendum	Fairview and Walter	"	"	110
Proctor	" " "	"	"	305
Prospect	Linden and Brandon	"	"	544
Roslindale ave.	Cornell and Beech	"	"	455
Selwyn	Hewlett and Farquhar	"	"	41
S. Walter	Robert and S. Fairview	"	"	100
Sycamore	Poplar and Hathorne	"	"	24
Temple	Willow and Keath ave.	"	"	486
Argyle road	Commonwealth ave. and Chiswick road,	Brl.	"	245
Aldie	Franklin and Everett	"	"	402
Appleton road	From Lake	"	"	556
Dustan	Cambridge and No. Beacon	"	"	162
Faneuil	Bigelow and Washington	"	"	183
George	Spring and No. Beacon	"	"	416
Hill	Murdock and Lucas	"	"	171
Kinross road	Commonwealth ave. and Sutherland road,	"	"	598
Western ave.	Market and the bridge	"	"	129
	Total 8-inch			20,092
Albany-st. yard	From Albany	B.	6	83
Commonwealth ave.	Kenmore and Brookline ave.	"	"	313
Lenox	Reed and Harrison ave.	"	"	213
Newcomb	" " "	"	"	216
St. Stephens	From Gainsborough	"	"	83
Willow	Beacon and Mt. Vernon	"	"	35
	<i>Carried forward</i>			943

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			943
Douglass	Eighth and Ninth	S.B.	6	228
East Fifth	H and I	"	"	251
Howell	Boston and Dorchester ave.	"	"	122
Old Harbor pl.	Old Harbor and Atlantic	"	"	48
West Broadway	F and Dorchester	"	"	758
Webster pl.	From Fifth	"	"	172
Bremen	Curtis and Saratoga	E.B.	"	138
Falcon	Meridian and Brooks	"	"	641
Morris	Putnam and Brooks	"	"	116
Wordsworth	Bennington and B., L., & R. B. R.R.	"	"	84
"	Pope and Saratoga	"	"	275
Buckley ave.	From Johnson ave.	Rox.	"	156
Burney	Tremont and Dell ave.	"	"	53
Dacia	Dove and Dalmatia	"	"	133
Duncan	Ruggles and Ward	"	"	84
Eldora	Hillside and Sunset	"	"	270
Edgewood park	From Edgewood	"	"	86
Farnham	Gerard and Reading	"	"	110
Grotto glen	From Day	"	"	101
Holborn park	From Holborn	"	"	132
Hammet ave.	Weston and Sarsfield	"	"	132
Hutchings	Harold and Humboldt ave.	"	"	55
Hygeia road	Gaston and Blue Hill ave.	"	"	513
Ingleside	Dacia and Blue Hill ave.	"	"	144
Intervale	Warren " " "	"	"	601
Johnson ave.	Centre and Buckley ave.	"	"	23
Juniper	Thornton and Juniper terrace	"	"	202
Kent	Roxbury and Vernon	"	"	210
Linden Park	Simmons and Linden ave.	"	"	212
Mansur	Day and Schiller	"	"	104
Moreland	From Dennis	"	"	33
Posen	" Arklow	"	"	64
Rand pl.	" Rand	"	"	113
Sunset	Hillside and Eldora	"	"	136
Smith	Whitney and Bumstead lane	"	"	231
	<i>Carried forward</i>			7,694

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			7,694
Shepard	From Tremont	Rox.	6	213
Schiller	Minden and Heath	"	"	245
Southwood	Edgewood and Blue Hill ave.	"	"	135
Street	From Heath	"	"	157
Vine	Dudley and Forest	"	"	140
Willow Park	From Shawmut ave.	"	"	149
Blomedon	" Tolman	Dor.	"	193
Bellevue	Quincy and Kane	"	"	48
Barnes	Dorchester ave. and O. C. R R.	"	"	328
Brent	Washington and Carlisle	"	"	378
Birch	Lauriat ave. and Oak terrace	"	"	52
Bicknell	Harvard and White	"	"	301
Court	From Stoughton	"	"	184
Coolidge ave.	Standish and Warner ayes.	"	"	241
Cook's court	From Fremont pl.	"	"	170
Corwin	Westville and Arcadia	"	"	43
Chipman	Norfolk and Torrey	"	"	51
Chapman ave.	Birch and Lyons	"	"	317
Coffey	Newhall and Neponset ave.	"	"	46
Ditson	Leroy and Josephine	"	"	113
Dean ave.	From Howard ave.	"	"	163
Ellet	Adams and Dorchester ave.	"	"	99
Evelyn	Norfolk and Blue Hill ave.	"	"	646
Elmont	From Waterlow	"	"	192
Edwin	" Dorchester ave.	"	"	1,148
Fremont pl.	" Fremont	"	"	333
Gayland ave.	" Judson	"	"	112
Gibson	Adams and Dorchester ave.	"	"	36
Greenhays	Magnolia and Cedar	"	"	170
Humphrey sq.	Dudley and Iowa	"	"	60
Hodges court	From Norfolk	"	"	162
Harlow	" Harlow	"	"	69
Hartford pl.	" Washington	"	"	163
Howe	" Hancock	"	"	197
	<i>Carried forward</i>			14,753

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			14,753
Howard pl.	From Howard ave.	Dor.	6	167
Intervale park	Upland and Bournside	"	"	531
Jones ave.	Ballou and Pratt	"	"	321
Kenwood	Allston and Seaborn	"	"	187
Lombard	Bushnell and Carruth	"	"	446
Leroy	Ditson and Geneva ave.	"	"	144
Mattapan	Blue Hill and Tileston ayes.	"	"	289
Miller's lane	Washington and Baker pl.	"	"	139
Mellen	Ashmont and Ocean	"	"	446
Merlin	W. Park and Jackson pl.	"	"	509
Marlow	Park and Vinson	"	"	371
Moultrie	From Seaborn	"	"	402
Morse	Washington and Bowdoin ave.	"	"	83
Nixon	Mather and Centre	"	"	237
Neponset ave.	Tileston and No. Munroe terrace	"	"	60
Oleander	Bird and Alexander ave.	"	"	176
Percival ave.	Church and Fox ave.	"	"	37
Patterson	Codman and Brook	"	"	177
Roslin	Harley and Washington	"	"	220
Richview	From Hillside	"	"	146
Stanton	Norfolk and Evans	"	"	209
Shawmut park	From King	"	"	244
Street	" Dalmatia	"	"	161
Saco	" Neponset ave.	"	"	212
Sidney pl.	" Waterloo	"	"	372
Columbia terrace	" Columbia	"	"	132
Shenandoah	Carruth and O. C. R.R.	"	"	379
Sagamore	Belfort and Romsey	"	"	151
Spring	Savin Hill ave. and Bay	"	"	261
Spencer	Wheatland and Talbot ayes.	"	"	195
Street	From Tolman	"	"	179
Savin Hill ave.	Spring and Gramplan way	"	"	124
Tileston ave.	Walk Hill and Mattapan	"	"	15
Upland	Park and Melville ave.	"	"	778
	<i>Carried forward</i>			23,253

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			23,258
Upbam	Hancock and Cushing ave.	Dor.	6	139
Vanghan ave.	From Geneva	"	"	24
Vinson	Park and Marlow	"	"	677
Waterloo	Harvard and Elmont	"	"	42
Westville	Draper and Corwin	"	"	107
Wentworth	From Norfolk	"	"	363
Wrentham park	Dorchester ave. and O. C. R.R.	"	"	221
Walton	Harley and Washington	"	"	183
Arundel	Selwyn and Centre	W.R.	"	404
Boylston terrace	Centre and Boylston	"	"	1,205
Boynnton	Centre and Call	"	"	200
Cross	Augustus and Hillside ave.	"	"	55
Cranston	Sheridan and Sheridan ave.	"	"	36
Elgin	Hillcrest and O. C. R.R.	"	"	98
Franklin park	From Morton	"	"	514
Guernsey	South and O. C. R.R.	"	"	350
Hillside ave.	From Wenham	"	"	55
Hastings	Centre and Carl	"	"	335
Havey	From Dudley ave.	"	"	168
Hillcrest	Loretto and Elgin	"	"	307
Lamartine terrace	From Lamartine	"	"	159
Loretto	Centre and Hillcrest	"	"	540
Linden	Prospect and Brandon	"	"	258
Newbern	Canterbury and Hyde Park line	"	"	220
Plainfield	Williams and Keyes	"	"	115
Perham	Mt. Vernon and O. C. R.R.	"	"	642
Peter Parley road	Forest Hill and Washington	"	"	121
Paul Gore	Danforth and Chestnut ave.	"	"	387
Richards ave.	Huntington ave. and Hyde Park line	"	"	36
Robert	Brookfield and So. Walter	"	"	32
Rockview	Green and St. John	"	"	321
Street	From Paul Gore	"	"	143
St. Thomas	Woodman and South	"	"	91
Street	From Wenham	"	"	190
	<i>Carried forward</i>			31,986

Statement of Location, Size, etc. — *Concluded.*

In what Street.	Between what Streets.	District.	Size.	Length.
	<i>Brought forward</i>			31,986
Wenham	Weldon and Yale	W.R.	6	423
Walter	Centre and Bussey	"	"	555
Alcot	Mansfield and Franklin	Bri.	"	334
Bayard	Kenneth and Weitz	"	"	60
Berwick road	Commonwealth ave. and Chiswick road,	"	"	419
Brentwood	Franklin and Athol	"	"	248
Chiswick road	Englewood ave. and Selkirk road . . .	"	"	660
Duck lane	Smith and Western ave.	"	"	359
Dunboy	High and Faneuil	"	"	96
Everett terrace	From Westford	"	"	190
Garden	Murdock and Lucas	"	"	202
Leicester	Surrey and Washington	"	"	121
Lawrence	From Market	"	"	202
Nantasket ave.	Washington and Union	"	"	222
Street	From Webster	"	"	50
Shannon	Washington and Union	"	"	170
Surrey	Market and Leicester	"	"	222
Surrey pl.	From Surrey	"	"	142
Street	" Murdock	"	"	217
Selkirk road	Sutherland and Kilsyth roads	"	"	112
Street	Duck lane and N. Harvard	"	"	180
Tremont	Washington and Newton line	"	"	195
Westford	Raymond and Raymond	"	"	217
Westford pl.	From Westford	"	"	108
Long island			"	2,874
Gallop's island			"	991
Thompson's island			"	6,772
	Total 6-inch			48,327
Doody's court	From Geneva ave.	Dor.	4	143
Humboldt park	" Bower	Rox.	"	33
Maiden lane	Reading and Hampden	"	"	41
Street	From Heath	"	"	139
Street	" Centre	"	"	154
Thompson's island			"	155
	Total 4-inch			665

Statement of Pipes Lowered.

In what Street.	Between what Streets.	District.	Size.	Length.
Dorchester ave. . . .	Richmond and Codman	Dor.	12	434
Dorchester ave. . . .	Barnes and Welles ave.	"	"	246
Franklin park	From Morton	W.R.	"	213
	Total 12-inch			893
Falcon	Brooks and Putnam	E.B.	6	250
Clarkson	Quincy and Barrington	Dor.	"	260
Sawyer ave.	Savin Hill and Cushing aves.	"	"	125
Hillside ave.	From Wenham	W.R.	"	136
Street	From Wenham	"	"	157
Yale	Wenham and Wachusett	"	"	115
Englewood ave. . . .	Chiswick road and Chestnut-hill ave.	Bri.	"	163
	Total 6-inch			1,206
RELAI'D.				
Brookline ave.	Francis and Tremont	Rox.	40	213
LAID BLOW-OFF.				
Swett	Near N. Y. & N. E. R.R. bridge	Rox.	12	14
Washington	LaGrange and Cottage	W.R.	4	14
ABANDONED BLOW-OFF.				
Tremont	Heath and Brookline line	Rox.	4	59

**Pipes Abandoned during the Year ending January 31,
1893.**

In what Street.	Between what Streets.	District.	Size.	Length.	Size of Pipe Relaid.
Berkeley	Over the B. & A. R.R. bridge	B.	12	213	12
Tremont	Heath and Brookline line	Rox.	"	98	
Franklin park . .	From Morton	W.R.	"	455	6
	Total 12-inch			766	
Lincoln	Cambridge and Franklin	Bri.	8	281	
Stanhope	Berkeley and O. C. R.R.	B.	6	680	8
Temple	Hancock and Derne	"	"	45	
Shepard	From Tremont	Rox.	"	22	
Small-pox hospital	" Swett	"	"	329	
Westminster . . .	Ruggles and Williams	"	"	378	12
Savin Hill ave. . .	Spring and Grampian way	Dor.	"	250	6 and 12
Taylor	Water and Franklin	"	"	172	10
Water	Walnut and Taylor	"	"	307	12
	Total 6-inch			2,183	
Albany-street yard	From Albany st.	B.	4	320	6 and 8
Boylston sq. . . .	Boylston and Washington	"	"	238	8
Chatham row . .	Chatham and State	"	"	153	8
State	Devonshire and Washington	"	"	145	8
Texas	Tremont and Elmwood	Rox.	"	184	8
	Total 4-inch			1,040	

Table showing the Length of Supply and Distribution Mains laid, and the Number of Stopcocks established, during the Year 1892, and the Length connected with the Sudbury and Cockituate Works, January 31, 1893.

	DIAMETER IN INCHES.													Total.	
	60	48	40	36	30	28	24	20	16	12	10	8	6		4
EASTERN DIVISION.															
Length in use Jan. 31, 1892 . .		25,571	23,054	20,844	57,549	244	57,859	59,484	69,876	775,905	43,823	314,200	1,140,408	126,924	2,715,741
Stopcocks in same		1	7	12	23		47	36	100	1,171	56	599	2,986	637	5,675
Length laid or relaid during the year					3,425		205		895	19,637	1,214	20,092	48,327	665	94,460
Stopcocks in same				2	2		2	1	2	41	4	54	126	11	245
Length abandoned during the year										766		281	2,183	1,040	4,270
Stopcocks in same									1	2		1	15	7	26
Length in use Jan. 31, 1893 . .		25,571	23,054	20,844	60,974	244	58,064	59,484	70,771	794,776	45,037	334,011	1,186,552	126,549	2,805,931
Stopcocks in same		1	7	14	25		49	37	101	1,210	60	652	3,097	641	5,894
WESTERN DIVISION.															
Length in use Jan. 31, 1893 . .	266	16,051	1,435	1,166	2,140				20	2,043			360		23,481
Stopcocks in same		5		3					2	4			2		16
Total connected with the works Jan. 31, 1893	266	41,622	24,489	22,010	63,114	244	58,064	59,484	70,791	796,819	45,037	334,011	1,186,912	126,549	2,829,412, or 555.87 miles.

Statement of Hydrant, Blow-off, and Reservoir Pipes, January 31, 1893.

	DIAMETER IN INCHES.					Total.
	16	12	9	8	6	4
Total length in use February 1, 1892	272	6,872	3,044	28	15,125	10,878
Length laid or relaid during the year . . . . .	.....	14	.....	.....	1,212	14
Length abandoned during the year		39	21		33	60
	272	6,847	3,023	28	16,304	10,832
						37,206

WATER-SUPPLY DEPARTMENT.

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Statement of Service Pipes Laid and Abandoned during the Year ending January 31, 1893.

SIZE OF SERVICE.	BOSTON.		SOUTH BOSTON.		EAST BOSTON.		ROXBURY.		DORCHESTER.		WEST ROXBURY.		BRIGHTON.		TOTALS.
	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	
8-inch laid									1	30					1
3 " "	2	140	2	44			2	236							6
4 " "	27	748	1	19	1	14	5	164			1	24			35
3 " "	13	303	2	44	1	18	8	267	1	213	2	167	1	24	23
3 " abandoned	1	15									1	11			2
2 " laid	14	292	2	54			5	62							21
2 " abandoned	2	88													2
1½ " laid	9	162			2	57	1	42	1	30	1	20	1	15	15
1 " abandoned	9	148			1	20									10
1¼ " laid	14	400					4	100			3	47	1	19	22
1¼ " abandoned	1	30													1
1 " laid	54	1,442	9	258	5	124	22	671	4	44	3	54	2	36	99
1 " abandoned	12	335	1	31	1	7	2	45	3	71	1	42	1	15	21
" laid	59	1,889	8	154	3	98	57	1,701	4	82	8	187	2	70	141
" abandoned	4	86	3	57	1	7	3	57	1	13			2	48	14
" laid	86	1,952	115	2,972	176	5,113	486	11,648	623	14,297	404	8,896	189	4,334	2,079
" abandoned	121	2,849	3	98	20	469	12	313	11	232	5	78	6	69	178
" "	4	106	3	109	4	119	11	303							22
Total laid	278	7,358	139	3,545	188	5,424	590	14,891	634	14,086	422	9,395	196	4,498	2,447
" abandoned	164	3,637	10	295	27	622	28	718	15	316	7	131	9	132	250
Net increase	124	3,701	129	3,250	161	4,802	562	14,173	619	14,380	415	9,264	187	4,366	2,197

Meters in Service, January 31, 1893.

COCHITUATE.	DIAMETER IN INCHES.								Total.
	6	4	3	2	1½	1	¾	⅝	
Worthington	1	10	22	115	98	550	436	78	1,310
Crown	2	18	32	36	80	206	241	1,172	1,787
B. W. W.	...	...	...	...	...	...	319	...	319
Hersey	...	1	5	11	23	38	76	19	173
Metropolitan	...	...	...	...	...	51	242	4	297
Ball & Fitts	...	...	...	...	...	1	3	4	8
Thomson	...	...	...	1	1	1	2	6	11
Desper	...	...	...	...	...	...	2	2	4
Nash	...	...	...	...	...	...	...	2	2
Am. Frost	...	...	...	...	...	...	1	...	1
	3	29	59	163	202	847	1,322	1,287	3,912

Meters Applied.

COCHITUATE.	DIAMETER IN INCHES.								Total.
	6	4	3	2	1½	1	¾	⅝	
Worthington	...	...	...	5	4	18	37	1	65
Crown	1	3	2	4	9	6	22	38	85
B. W. W.	...	...	...	...	...	...	1	...	1
Hersey	...	...	...	...	3	...	3	1	7
Metropolitan	...	...	...	...	...	22	28	...	50
Nash	...	...	...	...	...	...	...	1	1
Am. Frost	...	...	...	...	...	...	1	...	1
	1	3	2	9	16	46	92	41	210

Meters Discontinued.

COCHITUATE.	DIAMETER IN INCHES.							Total.
	4	3	2	1½	1	¾	⅝	
Worthington		1	4	3	9	16	7	40
Crown	1		2	4	3	3	59	72
B. W. W.						15		15
Hersey			2		2			4
Metropolitan					1	4		5
Thomson							1	1
	1	1	8	7	15	38	67	137

Meters Purchased.

COCHITUATE.	DIAMETER IN INCHES.							Total.
	6	4	3	1½	1	¾	⅝	
Worthington	1	5	1	5	3	50		65
Crown	1	7	4	26	8	60		106
Hersey			1					1
Metropolitan					62	175		237
Thomson					1	1	2	4
Nash							2	2
	2	12	6	31	74	236	4	415

Meters sent to Factory for Repairs.

COCHITUATE.	DIAMETER IN INCHES.					Total.
	2	1½	1	¾	⅝	
Worthington		1	6	1		8
Crown			13	17	72	102
Hersey		1	2	3		7
Thomson		1				1
Metropolitan				2		2
	1	3	21	23	72	120

Meters in Service, January 31, 1893.

MYSTIC.	DIAMETER IN INCHES.								
	6	4	3	2	1½	1	¾	⅝	
Worthington	...	10	6	36	7	73	56	9	197
Crown	2	7	8	11	2	32	42	93	197
Hersey	...	1	...	3	2	6	...	...	12
B. W. W.	...	...	...	...	...	...	1	...	1
Ball & Fitts	...	...	2	1	...	...	...	...	3
Metropolitan	...	...	...	...	...	8	17	...	25
	2	18	16	51	11	119	116	102	435

Meters Applied.

MYSTIC.	DIAMETER IN INCHES.							
	4	3	2	1½	1	¾	⅝	
Worthington	2	1	3	1	2	6	...	15
Crown	1	1	...	...	...	3	10	15
Hersey	...	1	...	...	2	...	...	3
Metropolitan	...	...	...	...	7	9	...	16
	3	3	3	1	11	18	10	49

Meters Discontinued.

MYSTIC.	DIAMETER IN INCHES.					Total.
	3	2	1	¾	⅝	
Worthington	...	2	4	1	...	7
Crown	...	...	1	3	6	10
Hersey	...	1	...	2	...	3
	1	2	7	4	6	20

Meters sent to Factory for Repairs.

MYSTIC.	DIAMETER IN INCHES.			Total.
	1	$\frac{3}{4}$	$\frac{5}{8}$	
Worthington . . . . .	.....	3	.....	3
Crown . . . . .	.....	5	11	16
Hersey	1	.....	.....	1
	1	8	11	20

Meters Repaired in Service.

CAUSES.	Cochituate.	Mystic.
Leak at spindle	62	8
“ coupling	38	9
“ packing	9	
“ stopcock	2	
Clock broken	32	17
“ defaced	17	6
Spindle broken	3	
Gear “	4	
Lever “	2	3
Pawl “	1	
Ratchet “	1	3
Stopped by fish	6	15
Don't register	45	12
Piston-rod broken . . . . .	.....	2
Clock detached . . . . .	.....	2
	222	77

Meters Changed.

CAUSES.	Cochituate.	Mystic.
Ordered out for test	208	5
Would not register	272	60
Injured by hot water	9	
No force	133	5
Burst	33	
Body broken	2	
Gear "	3	3
Clock "	43	5
Valve "	1	
Spindle "	2	1
Enlargement of service	46	1
Clock defaced	12	3
Leak at spindle	37	
Stopped by frost	39	
" " solder	2	
Leak at body	20	
" " coupling	10	
Lever broken		1
Defective packing		3
Stoppage		2
	872	89

General Statement of Meters for the Year ending January 31, 1893.

	COCHITUATE.		MYSTIC.	
	Meters.	Boxes.	Meters.	Boxes.
In service, January 31, 1893	3,912		435	
New set	210	62	49	14
Discontinued	137		20	
Changed	872		89	
Changed location	21		1	
Tested at shop	1,813		138	
Repaired at shop	330		27	
Repaired at factory	120		20	
Repaired in service	222	31	77	55
Purchased	415			

Hydrants Established and Abandoned during the Year.

	ESTABLISHED.					ABANDONED.					Increase.
	Lowry.	Post.	B. Lowry.	Boston.	Total.	Lowry.	Post.	B. Lowry.	Boston.	Total.	
Boston	2	9	1	..	12	..	..	2	6	8	4
South Boston	..	3	..	..	3	..	..	..	3	3	..
East Boston	..	4	..	..	4	..	..	..	..	..	4
Roxbury	2	17	4	..	23	3	..	2	4	9	14
Dorchester	4	61	18	1	84	4	..	10	5	19	65
West Roxbury	5	43	5	..	53	..	..	7	1	8	45
Brighton	5	12	4	1	22	1	2	4	1	8	14
Thompson's Island	..	2	..	..	2	..	..	..	..	..	2
	18	151	32	2	203	8	2	25	20	55	148

Total Number of Hydrants in Use, January 31, 1893.

	Lowry.	Post.	B. Lowry.	Boston Y.	Boston.	Totals.
Boston	673	227	68		518	1,486
South Boston	211	87	20	1	262	581
East Boston	138	84	24		138	384
Roxbury	667	163	65		97	992
Dorchester	574	363	187		72	1,196
West Roxbury	119	414	159		50	742
Brighton	77	256	59		36	428
Deer Island		16				16
Brookline	5				3	8
Chelsea					7	7
Quincy		7				7
Long Island		4				4
Thompson's Island		2				2
	2,464	1,623	582	1	1,183	5,853

Water-Posts.

DISTRICT.	Put in during the year.	Abandoned during the year.	Number now in Service.
Boston	20		42
East Boston	1		23
South Boston	8		25
Roxbury	8	1	60
Dorchester	13	2	72
West Roxbury	6		59
Brighton	17	1	39
Totals	73	4	320

Repairs of Pipes during the Year ending Jan. 31, 1893.

	DIAMETER OF PIPES IN INCHES.																			Total.	
	48	40	36	30	28	24	20	16	12	8	6	4	3	2	1½	1¼	1	¾	½		
Boston	1	2	.	6	1	.	9	8	22	9	49	23	6	7	6	5	19	12	471	7	663
South Boston	.	.	.	.	.	.	2	.	3	.	3	1	1	.	1	.	1	.	142	7	161
East Boston	.	.	.	2	.	.	2	1	3	.	4	1	.	4	1	.	.	1	67	8	94
Roxbury	.	.	1	.	.	2	4	.	9	.	20	3	.	1	.	.	3	2	203	30	278
Dorchester	.	.	.	.	.	.	.	.	4	1	1	1	.	.	.	.	2	2	106	.	117
W. Roxbury	.	.	.	.	.	.	.	.	3	1	6	.	.	1	.	.	.	1	70	.	82
Brighton	.	.	.	.	.	.	.	.	.	2	.	1	.	.	.	.	.	.	45	.	48
Deer Island	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
Totals	1	2	1	8	1	2	17	9	44	14	83	30	7	13	8	5	25	18	1,104	52	1,444

Causes of leaks that have occurred on 4-inch and upwards :

Settling of earth	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14
Blasting	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Defective joints	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	74
“ pipes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
“ stopcocks	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
“ packings	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	78
“ stuffing-box	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12
In way of sewer trench	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
Cap blown off	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
																				—

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Of causes on 3-inch and less :

Settling of earth	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	209
“ service-box	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
“ sewer trench	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13
Gnawed by rats	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13
Eaten by soil	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18
Blasting	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Struck by pick	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50
Broken by steam-roller	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Changed grade of street	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	23
Changed location	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
Uprights in way of edgestone	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50
Pipe in way of sewer trench	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
Defective joints	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24
“ packing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14

Carried forward,

437

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<i>Brought forward,</i>	437	212
Defective coupling	26	
“ stopcock	45	
“ pipes	158	
Stopped by dirt	34	
“ gasket	11	
“ fish	45	
“ rust	363	
“ frost	113	
	—	1,232
		<u>1,444</u>

In addition to the above, 325 service-pipes were shut off for repairs inside of the street line, and notice of the same was sent to the On and Off Division of the Water-Income Department.

Hydrant barrels changed for repairs	263
Hydrant boxes renewed	98
Stopcock boxes renewed	191
Deacon meter boxes renewed	7

Statement of Leaks and Stoppages from 1850 to 1893.

YEAR.	DIAMETER IN INCHES.		Total.
	Four inches and upwards.	Less than four inches.	
1850	32	72	104
1851	64	173	237
1852	82	241	323
1853	85	260	345
1854	74	280	354
1855	75	219	294
1856	75	232	307
1857	85	278	363
1858	77	234	401
1859	82	449	531
1860	134	458	592
1861	109	399	508
1862	117	373	490
1863	97	397	494
1864	95	394	489

Statement of Leaks and Stoppages from 1850 to 1893.—
Concluded.

YEAR.	DIAMETER IN INCHES.		Total.
	Four inches and upwards.	Less than four inches.	
1865	111	496	607
1866	139	536	675
1867	122	487	609
1868	82	449	531
1869	82	407	489
1870	157	707	926
1871	185	1,380	1,565
1872	188	1,459	1,647
1873	153	1,076	1,229
1874	434	2,160	2,554
1875	208	725	923
1876	214	734	948
1877	109	801	910
1878	213	1,024	1,237
1879	211	995	1,206
1880	135	929	1,064
1881	145	833	1,028
1882	170	1,248	1,418
1883	171	782	953
1884	253	1,127	1,380
1885	111	638	749
1886	150	725	875
1887	172	869	1,040
1888	216	1,140	1,356
1889	183	849	1,032
1890	180	718	898
1891	179	758	952
1892	212	1,232	1,444

Respectfully yours,

WILLIAM J. WELCH,

Superintendent.

REPORT OF THE RESIDENT ENGINEER AND SUPERINTENDENT OF THE WESTERN DIVI- SION.

SOUTH FRAMINGHAM, January 1, 1893.

ROBERT GRANT, Esq., *Chairman Boston Water Board*:

SIR: The annual report for the Western Division of the Boston Water-Works is submitted herewith.

SUDBURY-RIVER BASINS.

Water-shed, 75.2 square miles.

The rainfall for 1892 was 40.96 inches at Framingham, and the mean rainfall taken at Framingham, Dam 4, and Cordaville, was 41.61 inches; about 6.39 inches below the average. The quantity of water has been sufficient, and the quality has been good. The very low rainfall in September and October caused heavy draughts upon the storage, but the dry period was hardly long enough to cause anxiety in regard to the supply. The greatly increased consumption of water, however, points to the necessity for a large increase at an early day.

Surveys have been continued throughout the year on different portions of the water-shed, principally in connection with the takings of land on the borders of the brooks and for the construction of additional basins. During the latter part of the summer and the whole of the autumn Basin 4 was drawn down for the use of the city, greatly to the benefit of the quality of water delivered.

The careful studies of the condition of the various sources of supply, already inaugurated, have been maintained during the year.

The construction of Basin 6 has been vigorously pushed during the working season. Almost all of the stripping has been finished, and the embankment forming the dam is now more than half completed. Another season will see this important work finished and ready to be filled in the winter of 1893-94.

The color of the water delivered to the consumers has been higher than in 1891, for reasons that will be alluded to farther on.

Basin 1.

Grades, H. W., 161.00; Stone Crest, 157.54.

Area, 149 acres; Greatest Depth, 14 ft.; Contents, 288,000,000 gals.

On January 1, 1892, this basin stood at elevation 157.00 above tide marsh level in Boston, from which all heights are reckoned. On January 3, waste over the crest began and continued until April 16, when both sets of flash-boards were put in place. The surface fell to 155.55 on April 29, then rose to the top of the flash-boards on May 12, and water was wasted, with the exception of a few days towards the last of May, until June 7. The water then gradually fell to 155.97 on September 24. Both sets of flash-boards were removed on August 24. During the remainder of the year the water was kept at about the level of the crest. The highest elevation was 159.60 on May 16, and the lowest 155.55 on April 29.

Water was drawn wholly from this basin for the supply of the city from January 9 to July 20, the water from the other basins being carried through Basin 1 on its way to the aqueduct. The 48-in. main in the bottom of this basin is in very poor condition, and a limited amount of water only can be drawn through it without causing trouble. It should be thoroughly repaired during the coming year and before the consumption in the city reaches such a point as to interfere seriously with the work. I renew my recommendation of last year that studies should be made at once for putting this basin in as good condition as Basins 2, 3, and 4, with a view to using it as an additional settling basin. A flow of at least one and one-half millions of gallons has been daily passed into the river below the dam in accordance with the law.

Basin 2.

Grades, H. W., 168.00; Stone Crest, 165.87.

Area, 137 acres; Greatest Depth, 17 ft.; Contents, 530,000,000 gals.

On January 1, 1892, the surface of the water was at elevation 163.55, and rising rapidly. On January 3 it flowed over the stone crest, and so continued until April 21, with the exception of four days in February and two days in March. Both sets of stop-planks were put in position on the above date, and on April 28 waste over the planks began. This overflow continuing an extra set of flash-boards was placed on top of the regular planks, and on May 11 the water had risen sufficiently to overflow, which did not cease until June 29. The surface then receded slowly.

On July 20 one of the gates was opened to draw the sup-

ply for the city, and the water fell to 161.36 on August 18, at which time the surface began to rise due to the drawing down of Basin 4. On September 23, one set of flash-boards was put in place to prevent overflow, and on October 8 the water reached grade 166.03. On November 19 the flash-boards were removed and water began to run over the crest. The basin was kept full with slight waste at times until December 12, when the water began to fall, reaching 163.30 on December 31. The highest elevation during the year was on May 23, 167.97, and the lowest on November 10, 159.54.

Water for the supply of the city was drawn wholly from this source from January 1 to January 5; August 26 to August 29; August 31 to September 10; September 12 to November 5; November 17 to November 19; November 20 to November 21; November 25 to November 27; November 29 to November 30; and from December 9 to December 11.

The supply was drawn partially from this basin and partially from Basin 3 from July 20 to August 23; August 23 to August 26; August 29 to August 31; September 10 to September 12; November 5 to November 17; November 19 to November 20; November 23 to November 25; November 30 to December 1; December 1 to December 4; December 7 to December 9; and from December 11 to the end of the year.

Until April there were very few organisms in Basin 2. During the spring there was a slight growth of *Synedra*, followed by a slight growth of *Cyclotella*. The latter were again abundant in September, decreasing during October and increasing again greatly during November. They disappeared suddenly during the last part of November. These *Cyclotella* were very minute. *Protococcus* was present from April to November, and was most abundant during July and August.

Cedar swamp, about eight miles above Basin 2, furnishes a breeding place for many troublesome organisms, which, under favorable conditions, may develop in great numbers and be carried down to stock the reservoirs below. A notable instance occurred during the month of August, 1892.

During the first week of this month there was a great quantity of *Anabaena* (Cyanophyceae) in Cedar swamp pond, about 8,400 filaments per c.c.

On August 15, after a rain, the *Anabaena* was carried down stream and into Basin 2, where 2,064 filaments per c.c. were found at the upper end of the basin. A week later it was abundant at the gate-house and on the screens at Farm

pond, and immediately afterwards appeared at the terminal chamber at Chestnut-hill Reservoir, where there were 326 filaments per c.c. By September 1 it had become distributed through the reservoir, and was found in small quantities in the city taps. The *Anabæna* flourished in Basin 2 for about a month; then it gradually decreased and by October 17 had practically disappeared. The filaments were quite long, many of them being over one millimeter in length and easily seen with the naked eye. When present in great quantities the water assumed a turbid appearance, and at times had a peculiar taste varying from time to time and described by Mr. Whipple as resembling the taste of a nasturtium stem, and sometimes distinctly oily or musty. The taste could not be traced to the city taps.

This abnormal growth of *Anabæna* appeared in Cedar Swamp pond immediately after the hot weather in July. The history of its development and passage through the basins and aqueducts is interesting as showing the influence of these particular dangers and the great advantage of abundant storage between the sources of supply and the city taps.

The average color of the water in Basin 2 at the surface, mid-depth, bottom, and throughout the extent of the basin, with the exception of a slight increase at the inlet, is remarkably uniform. It has been almost exactly 1.01 throughout the year.

Basin 3.

Grades, H. W., 177.00; Stone Crest, 175.24.

Area, 283 acres; Greatest Depth, 21 feet; Contents, 1,081,000,000 galls.

On January 1, 1892, this basin stood at elevation 167.19, and on the 18th had risen high enough to flow over the stone crest, and continued to overflow until June 25, except for a number of days in February, March, and May, due to the waste-gates having been opened, and a few days in June when the experiment was tried of placing temporary flash-boards on the dam. The water fell to grade 169.14 on August 26, due to drafts for the supply, and the surface was kept at about this level until November 16. After this date the water rose gradually, and on December 12 reached 174.50, and on the 31st was at 171.86.

The highest point reached during the year was 176.17 on June 14 and the lowest 167.19 on January 1.

Water for the supply of the city has been at no time drawn solely from this source, but has occasionally been drawn partly from this basin and partly from Basin 2.

On August 8 it was noticed that the water at the bottom of the basin had quite a strong musty taste, but at no time during the year has the water been as bad as usual.

The spring growth of diatoms was large; *Synedra* and *Asterionella* developed first, the latter soon disappearing. The *Synedra*, however, remained abundant through May. Then came a growth of *Tabellaria* continuing through July, followed by a short run of *Cylotella*. *Chlorophyceæ* and *Cyanophyceæ* (*Microcystis* and *Cælospherium*) were unusually abundant during the summer; the latter developed to such an extent during the last of August and the first of September that a thick scum was frequently seen on the surface. *Tabellaria* and *Asterionella* grew rapidly during September and October. In November the latter disappeared, but the former flourished during the remainder of the year.

The mean temperature of the water has been about $52\frac{1}{2}^{\circ}$ Fahr. The mean color has been somewhat higher than in 1891.

Plans have been perfected for a filter basin on the Marlboro' brook. Surveys and plans were completed for takings on the line of this brook, and on October 25th a taking was made of about 32.8 acres of land in the City of Marlboro' for the purpose of preventing future pollution, as population extends, and for the purpose of building filter beds to filter the waters of the brooks before discharging them into the feeders to the basins. The result of this experiment cannot be accurately foretold.

Basin 4.

Grades, H. W., 215.21; Stone Crest, 214.21.

Area, 162 acres; Greatest Depth, 49 feet; Contents, 1,416,400,000 galls.

On January 1, 1892, the surface of this basin stood at elevation 207.85. The water gradually rose and on January 21 was flowing over the stone crest. This waste continued until April 25, when the lower set of flash-boards was set in position. May 3, the basin was wasting over the flash-boards, and so continued until May 22, when the boards were removed. On May 31 they were restored, and on June 2 the second set added. June 10, the water began to run over the second set, and so overflowed until July 17. On August 16 the supply for the city was drawn from this source, and the basin was practically emptied during the remainder of the summer and the autumn. The water was drawn down to grade 185.34 on November 5, the lowest point reached during the year. About twenty-nine feet of water were used and contributed materially to keep up the quality of the supply in the city.

The flow of Cold Spring brook has been continuously gauged at the inlet to the basin to form an estimate of the influence of the storage in the soil surrounding the basin, on the available quantity of the supply.

During the autumn the basin force was employed in grading and planting the grounds around the new outlet channel and in repairing damages caused by the construction force last year.

The quality of the water has been excellent during the whole year. The prevailing organism has been the *Cyclorella*. It was present in January, again in May and June, and again in October, November, and December when the numbers were unusually high. The organisms were very minute however, and the figures reported do not represent correctly the amount of organic matter present. This subject of quantity *versus* numbers will be discussed more fully under another heading. There were two short growths of *Synedra* in May, June, and October. *Protococcus* in small quantities was present at all times.

The color of the inlet averaged 1.43 this year against 1.23 in 1891, and the color of the water generally was higher than last year.

The drafts on this basin, coupled with the general studies made in the laboratory on the colors of the waters, has led me to the conclusion that it will be difficult, if not impossible, to maintain a standard of color throughout the year in the tap-water.

As the basins will be generally exhausted by the early winter, in the process of equalizing the flow, the supply must then be kept up by the more direct flow of the streams, so that in the winter it is probable that the color of the water in Boston will be high compared with the rest of the year, or until the melting snows bring relief. This convinces me of the importance of carrying out the following plans in the near future: 1st, the judicious limiting of the consumption of water; 2d, the provision of storage on a more generous scale than it is now customary to provide for, even with our liberal figures; and 3d, the securing of a large area in the country adjacent to the aqueducts for the filtration of the supply, a measure which I believe the future will demand.

WHITEHALL POND.

Elevation, H.W., 327.91; Bottom of Gates, 317.70; Area, 608 acres; Contents, 1,237,000,000 galls.

On January 1, 1892, the surface of the water in this pond stood at elevation 322.93, or 4.98 feet below high water. The pond then gradually rose to 325.10 on April 10, then

tell to 324.89 on April 29, again rose to 325.42 May 29, the highest point reached during the year, and then gradually receded to 322.39 November 9, the lowest point reached. The pond then rose slowly to 323.06 on December 31.

The gates were closed from 7 A.M. November 29 to 7 A.M. December 12. During the remainder of the year one gate has been partially open all the time to provide water for the mills as they wish to use it. A weir measurement has been kept of the amount of the flow from the water-shed. Owing to the dry season it has been unnecessary to waste any water from Whitehall pond during the year. In fact, with the ordinary supply drawn for the mills, the pond has not filled during the year.

The dredging plant built last year has been anchored securely in the pond and regularly inspected. During the summer the decks were wet down twice a day to prevent them from opening.

Daily heights are now kept of this pond, and the influence of its storage taken into account in calculating the yield of the Sudbury-river water-shed.

Much time has been given during the year to questions connected with the suits for damages occasioned by the "taking," and there are now prospects of a speedy trial of what is known as the "Whitehall Pond case."

Hypothetical tables of yield of the 4.353 square miles, comprising the Whitehall-pond water-shed (20 per cent. water-surface), have been prepared covering sixteen years by months.

There was no unusual growth of organisms in this source of supply during 1892. In the winter Infusoria (*Glenodinium*, *Dinobryon*, and *Synura*) were abundant, chiefly in the shallow portions, which have been exposed during the greater part of the year. Late in the autumn *Uroglena* appeared at the outlet in small numbers, but sufficient to give an oily taste to the water.

The usual color of the upper pond was 0.50, and at the weir, or outlet, the color has been 0.90. On the shallow flowage the color varies from 0.70 to 2.00.

Farm Pond.

Grades, H.W., 149.25; Area, 165 acres; Contents, 167,500,000 galls.

On January 1, 1892, the water in this pond stood at elevation 148.99. The surface has been kept at about high-water mark during the year.

Water was drawn from this source for the supply of the city from 7 A.M. January 1 to 2 P.M. February 25, 7 A.M.

May 14 to 10 A.M. July 21, 7 A.M. August 18 to 1 P.M. August 22, and from 10 A.M. August 30 to 9 A.M. September 12.

The Framingham Water Company has pumped 82,800,000 gallons from the pond during the year, or 226,000 gallons daily. The highest elevation reached was 149.50 on May 23, and the lowest 147.96 on January 12.

LAKE COCHITUATE.

H. W., 134.36; Area, 800 acres; Capacity above 127.36, 1,508,000,000 galls.

January 1, 1892, the lake stood at elevation 127.34. The surface then rose to 132.43 on January 29. On that day water from the Sudbury was turned into the lake, and May 4 the surface stood at high water. From May 20 to May 28 the waste-gate was opened. June 20 the draught from the Sudbury was finally stopped. The lake fell to 127.53 November 13, and to 127.50 December 10; at this time the flow in the aqueduct was shut off and the surface rose to 128.39 December 31. The flash-boards have not been removed from the dam at the outlet during the year. The amount of water drawn from the Sudbury was 902,300,000 gallons and the amount wasted 281,000,000 gallons. Owing to lack of water we have been unable to carry on experiments at the outlet dam to determine the co-efficients of gate and roll-way.

At the beginning of the year *Melosira* and *Asterionella* were very abundant. In February the former declined, but increased again in March and April. During the first week in May they suddenly disappeared. *Asterionella* were present throughout the spring months. *Synedra*, *Tabellaria*, *Stephanodiscus*, and *Cyclotella* were present during this part of the year. In the winter, *Infusoria* (principally *Synedra*) were present under the ice and gave an unpleasant taste to the water. In June *Chlorophyceæ* (*Protococcus*) and *Cyanophyceæ* (*Microcystis*) appeared and remained abundant throughout the summer. In October, *Asterionella* developed even before the water turned over, the growth lasting about a month. It decreased during November and increased again in December, and was accompanied by a growth of *Stephanodiscus* and *Melosira*.

At the bottom, circulation ceased about the middle of April. The color gradually increased to 2.50, where it remained constant for three months. This color is not as high as has been obtained in previous years. The turning over occurred November 8-15. The mean temperature at the bottom during stagnation was 44.3 Fahr., and it only varied

two or three tenths of a degree from this temperature for three months. Temperatures were taken at intervals of five feet in the vertical during the period of stagnation, and they are shown in the accompanying plate. The averages of these temperatures compared with the averages for 1891 appear on the second plate. It will be noticed that the curves cross each other. The explanation is this: In 1891 the temperature of the air from April 15 to November 15 was higher than during the corresponding season in 1892, consequently the surface temperatures are higher in 1891; but in 1892 the hot weather came early, and the lower layers became warmer before circulation ceased.

The following examinations have been made of the brooks feeding the lake:

	No. of Obs.	Usual Color.	Minimum Color.	Maximum Color.
Snake brook, at mouth	11	0.45	0.12	0.95
Pegan brook, at mouth	11	0.15	0.07	0.40
Dug pond outlet	12	0.12	0.06	0.20
Course brook, at mouth	12	0.84	0.47	1.60
Beaver dam brook, at mouth	12	0.80	0.48	1.40

DUDLEY POND.

*Grades, H. W., 146.16; 18-inch Pipe, 130.36; 18-inch Pipe, 127.36.
Area, 81 acres; Greatest Depth, 27 feet; Contents, 250,000,000 galls.*

On January 1, 1892, the surface of the water in this pond was at elevation 139.46, or 7 feet below high water, and the stop-planks were out of the gate-chamber. When the planks were replaced on March 21 the elevation of the pond was still 139.46 and rose slowly to 139.81 on December 31. The masonry in the chamber having been in a bad condition for some time, advantage was taken of the low stage of water to repair the stonework. It was partially taken down and thoroughly relaid and pointed. The iron cover has been securely fastened and locked to prevent interference with the stop-planks.

SUDBURY-RIVER AQUEDUCT.

*Grades, 141.352 at Farm Pond; 124.051 at Terminal Gate-House.
Length, 15.89 miles; Size, 7 ft. 8 in. $\times$ 9 ft.; Capacity, 109,000,000 galls. 24 hours.*

The three portions of this aqueduct are in good condition. The supply and Farm-pond aqueducts were cleaned by machine on August 23 and November 22.

80 °

70 °

60 °

50 °

40 °

APR.

MAY.

JUNE

JULY

AUG.

SEPT.

OCT.

NOV.

surface

60

55

50

45

40

35

30

25

20

15

10

5

AVERAGES.

100

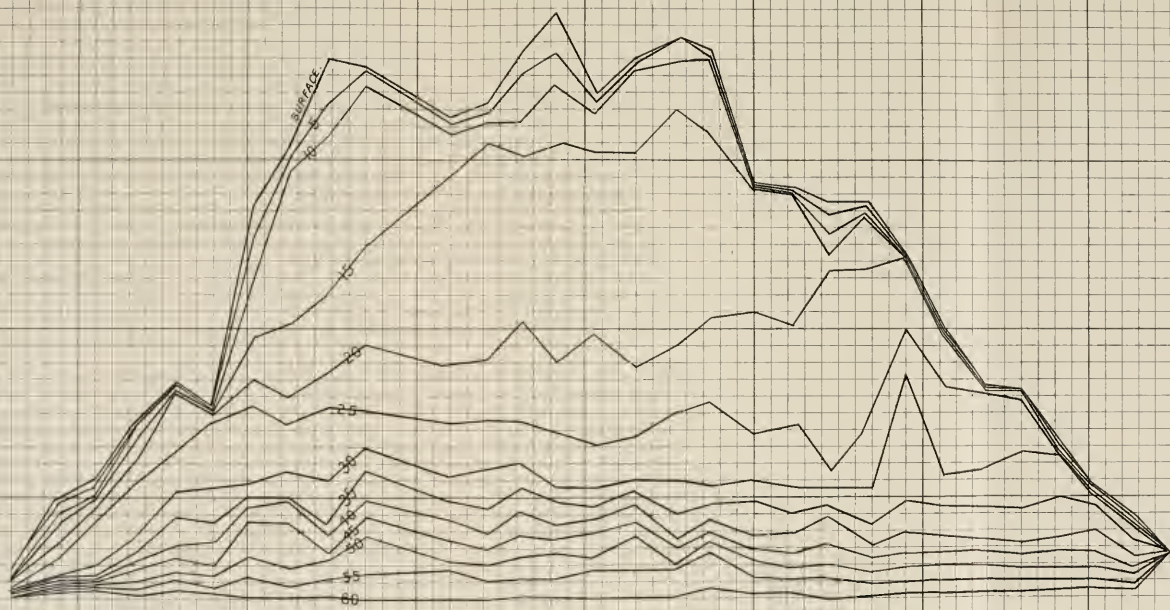
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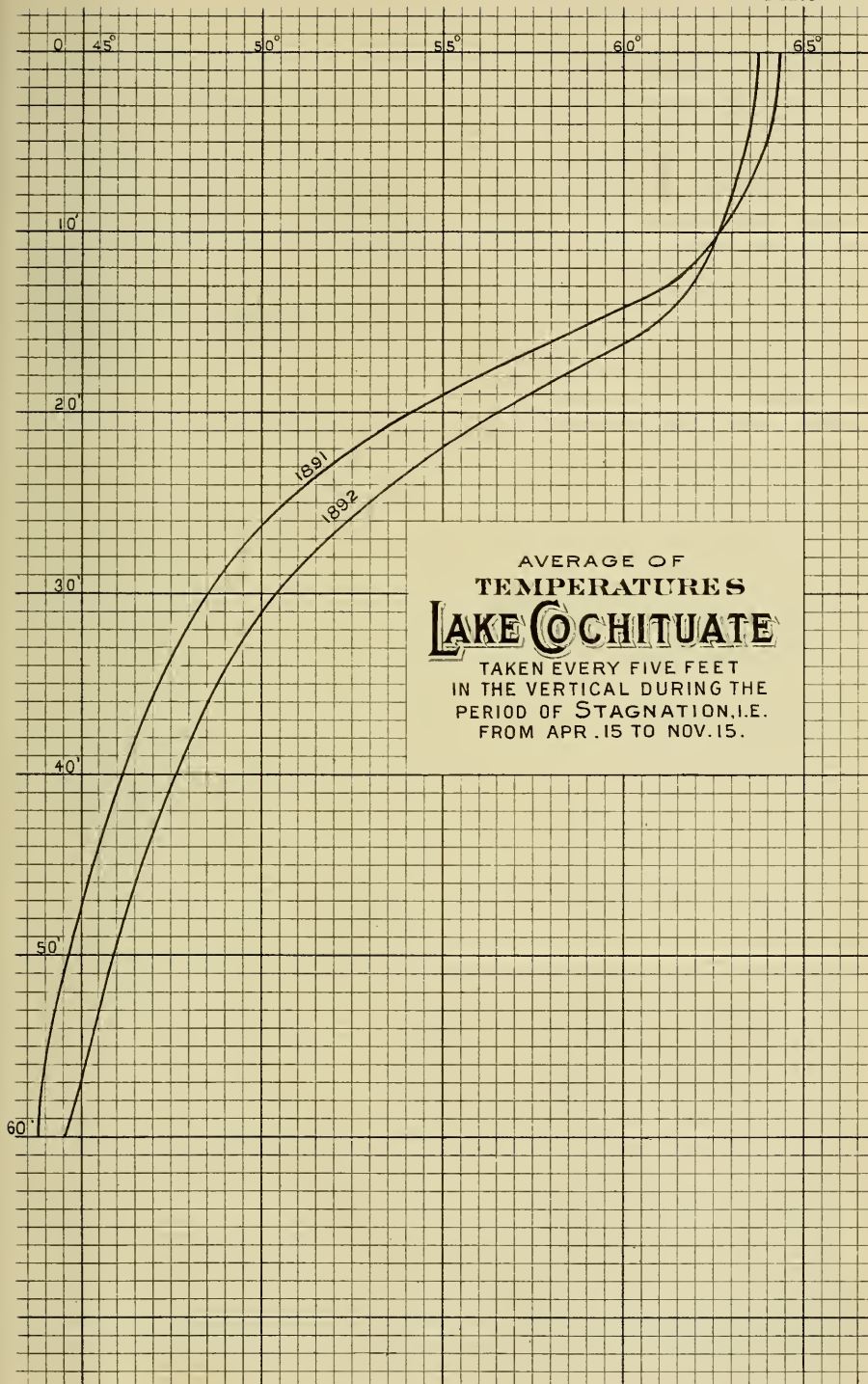
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TEMPERATURES
LAKE COCHITUATE
 1892.





The main aqueduct was cleaned by machine between Farm pond and the West Syphon Chamber on November 29, and by hand between the East Syphon Chamber and Chestnut-hill Reservoir on December 5 and 6.

The 48-inch pipe in Basin 1 has been twice flushed into the river below Dam 1.

Owing to work during the early part of the year on the Beacon-street tunnel, the main aqueduct has been in use only during 275 days. In addition, however, it was in use as far as Course brook waste-weir for 10 days. The supply aqueduct was in use for 285 days. As the supply for the city was drawn for some time from Farm pond, the Farm-pond aqueduct was in use only during 171 days, or 114 days less than the supply aqueduct.

The amount sent to the city has been 9,635,200,000 gallons, or a daily average of 26,320,200 gallons for the year. Besides the above, 902,300,000 gallons have been run to Lake Cochituate.

As the usual spring cleaning was omitted this year the interior of the aqueduct was very dirty in November. A heavy coating of black deposit was found throughout the whole length, with large patches of a fibrous growth filled with mud. The growth of *Spongilla Fluvialis* exceeded any previous experience with this aqueduct. It occurred in large patches all along the line, and the concrete bottoms of Rockland and Badger Hill tunnels were covered with the sponge.

From the West Pipe Chamber to the terminal gate-house the black deposit was not so extensive, but sponge was found in great patches, and in Beacon-street tunnel it was as bad as in the other tunnels. These facts emphasize the importance of semi-annual cleanings.

During the year the fences on the road crossings from Newton Centre to South Natick have been rebuilt. All the brush growing along the line has been mowed and repairs upon the embankments have been made.

It has been found necessary to mow the grass on all embankments. If this is not done, the roots of the grass decay and it affords a chance for the moles to burrow in winter, making holes in the embankments.

On January 14, 1892, the third season's work of lining the Beacon-street tunnel was begun. The track and tunnel were first cleaned and the bottom prepared. Centres were taken down and reset and one switch removed.

February 1, laying of concrete was begun at Stations 800 + 85 on the bottom and at 801 + 05 on the top, and on April 26 the work was completed to 798 + 10 on the bottom

and 798 + 18 on the top. About 280 feet of lining were put in place. The westerly end was finished with steps to facilitate the carrying on of the work in a westerly direction, should it be found necessary to continue the lining in the future from farther giving away of the roof. As it is not intended to do more at present, all the cars, tools, and materials were removed and the shanties sold at auction. The track only was left.

The total cost of the concrete laid during the year was \$12.85 per cubic yard. The following statistics cover the whole three seasons' work:

Lining begins Station	798+18
“ ends “	810
Total length	1,182 feet.
Rate of progress per day	6.4 “
Cubic yards of concrete	3,402
“ “ per lineal foot	2.88
Cement used, Portland cement	3,969 casks.
Rosendale cement	486 “
Total	4,455 casks.
Sand	8,910 “
Cracked stone	22,275 “
Total cost	\$55,685.40
Cost per cubic yard, including track and all expenses	\$16.37

No stone has fallen from the roof of the unlined portions during the year, with the exception of three small pieces about 10 pounds in weight, found December 5 at Station 793. The suits for damages at Rosemary brook, caused by flooding lands below the blow-offs, have been settled by the Law Department by the payment of \$1,176.82. As the city is liable for damages whenever water is let out of the aqueduct for cleaning or repairs, I recommend that steps be taken to secure the right to flood the low lands as far as Charles river.

COCHITUATE AQUEDUCT.

Grades, 121.03 at Lake; 116.77 at Brookline Reservoir.

Length, 14.60 miles; Size, 5 ft. X 6 ft. 4 in.; Capacity, 20,000,000 galls. per 24 hours.

This aqueduct has been in constant service throughout the year, with the exception of about twenty-five days, four days for cleaning, and after December 10, twenty-one days, on account of the construction of sewers in Newton.

A depth of six and one-half feet was maintained throughout the year, with the exception of three days in January, and from December 6 to December 10, when the lake was too low to permit this amount of water to be run.

The usual spring cleaning was omitted this year, but on November 14, 15, 16 the brick-work was swept from the lake to Brookline reservoir. The aqueduct was very dirty. From the lake to Station 28, one-half the surface was covered with sponge, and from this point to Station 80, Division 1, two-thirds of the surface was covered with the same growth. A large amount of sponge was found from Wellesley to Grantville waste-weir. From the East Chamber it was less abundant, and occurred in smaller patches as far as Brookline reservoir. The Newton tunnel was very dirty, a heavy black mud having settled there. Brookline tunnel showed some evidence of sewage, but in much less degree than formerly.

Plans were made in October by the city of Newton with reference to changing the line of Hammond's brook, near the Newton Centre waste-weir. As the plan involved a considerable lowering of the channel, it became necessary early in December to prepare for the work. The aqueduct was first uncovered as low as possible without interfering with the safety of the structure, and on December 10 water was shut off, and the flow to the city maintained wholly by the Sudbury-river aqueduct. The aqueduct was plastered inside to make it as water-tight as possible, and the brickwork hung up by chains supported from three 16-inch sticks extending across the trench, but notwithstanding these precautions the brickwork leaked so badly when the water was turned on, December 20, that the water was shut off again and more thorough repairs undertaken. Four additional chains were added, and they were tightened by jack-screws. The lagging around the aqueduct was pointed and grouted, and cavities back of the sheeting filled with concrete. The joints inside were cut out, pointed, and plastered for a distance of 125 feet. When water was finally let on, the repairs proved efficient in stopping all leaks. The work of building the masonry structure under the aqueduct is now in progress.

CHESTNUT-HILL RESERVOIR.

H. W., 125.00 ; Dam, 128.00 ; Effluent Pipes, 99.80.

Area, Lawrence Basin, 37.5 acres ; Contents, 166,000,000 ; Bradley Basin, 87.5 acres ; Contents, 391,000,000. Total contents above grade one hundred, 557,000,000 galls.

The work of changing the lines of the driveway near the intermediate and terminal gate houses was completed early in the season and shrubbery planted.

A large amount of work has been done on the grounds in connection with maintenance. The greater part of the fence separating the driveway from the reservoir was removed in July, the City Solicitor having given the opinion that there was no legal necessity for the fence. During the summer and autumn a great number of visitors resorted to the reservoir to enjoy the beautiful views. A hundred extra settees were placed in different portions of the grounds.

The mixtures of Sudbury and Cochituate water were so regulated as to produce the same resultant colors at the Chestnut-hill and Brookline effluent gate-houses. In 1891, when less perfect means were taken, the average color at Brookline was 0.10 lower than at Chestnut hill. In December, owing to the shutting down of the Cochituate flow, the colors were very much increased in the reservoirs and at the city taps, and a material reduction cannot be looked for until the breaking up of the ice.

BROOKLINE RESERVOIR.

H. W., 125.00; Area, 23 acres; Greatest Depth, 24 feet; Contents, 119,583,960 galls.

Everything in connection with the Brookline reservoir is in good order. One-half of the water used in Boston has been sent through this reservoir during the year. No other work beyond the usual maintenance has been done.

FISHER-HILL RESERVOIR.

H. W., 241.00; Pipe Inverts, 220.00; Depth, 21 feet; Contents, 15,400,000 galls. above 223.

The reservoir is in good condition. The grounds have been maintained as usual by the Chestnut-hill Reservoir force.

BIOLOGICAL LABORATORY.

This laboratory has turned out excellent work throughout the year, and proved a valuable adjunct to the proper management of the different sources of supply. Weekly examinations are still made of all the Boston waters and results recorded. Mr. E. C. Whipple is the assistant in charge of all the laboratory work.

During the year 2,310 microscopical and 2,160 bacteriological examinations of water have been made, besides numerous special studies of bacteria, algæ, infusoria, etc. The total number of microscopical examinations thus far made in the laboratory probably exceeds 7,000.

In addition to the regular weekly and monthly reports, 92 special reports have been made on subjects con-

nected with the filtration of water, and special examinations of the reservoirs, brooks, etc.

Good photographs have been taken of nearly all of the important organisms.

A radical change is to be made in the manner of recording the organisms present in a sample of water. Heretofore the actual number of the organisms have been counted without regard to their size. But inasmuch as their sizes vary considerably, an improvement has been made in the adoption of a standard unit. This unit is the same as that previously used for the estimation of the amorphous matter, *i.e.*, a square, 20 microns (.020 m.m.) on a side. After January 1, 1893, all results are to be expressed in terms of this standard unit.

During the year several problems connected with the taste and odors imparted to the water by certain organisms have been investigated. One of the most interesting occurred during January and February, 1892, when the reservoirs were covered with ice. At that time the water drawn from the taps had a slight but somewhat disagreeable taste, variously described as "bitter," "sweetish," "spicy," "fishy," etc. It was most noticeable on the dead ends and at places where little water was used. Careful microscopical examinations were made in all parts of the city, and wherever the taste was strongest, there was always found a comparatively large number of infusoria. Most important of these was the *Synura uvella*, a brown-colored, sphaeroidal colony, composed of from 25 to 80 individuals, joined together by their posterior extremities; the colony moving through the water with a tumbling motion. These infusoria and the accompanying tastes were traced backwards through the reservoirs and conduits till it was found that they originated in the northern division of Lake Coahuatla.

There they were most abundant immediately below the ice. Samples of the water from this spot had the same taste as was observed in the taps, only somewhat stronger. Experiments at the laboratory showed that when a sample of the water was filtered, the filtrate was quite free from taste, but that the organisms filtered out, had a strong taste, very characteristic and difficult to describe, but somewhat resembling a bitter almond, combined with a peculiar spicy taste. The infusoria did not increase to any great extent, either for want of food, or because the crustacea, which developed abundantly about that time, devoured them.

The four subjects reproduced on the heliotype plates accompanying this report were photographed in the laboratory.

Inspection of Pollutions Department.

The following is a digest of the operations of the department as reported by Mr. J. S. Concannon, Chief Inspector :

Legal notices sent	.	.	.	.	.	34
Cases inspected (old)	.	.	.	.	.	739
Cases inspected (new)	.	.	.	.	.	358

Of the 1,097 cases inspected, 489 are reported as "Remedied," 369 as "Safe at present," 41 "Seem safe," 44 "Suspected," 154 "Unsatisfactory."

No legal injunctions were found necessary during the year.

FILTRATION EXPERIMENTS.

Experiments on intermittent and continuous sand filtration have been conducted with depths of sand of from 34 to 63 inches, and rates of flow of 300,000 to 1,500,000 gallons per acre per day. The removal of color and the loss of head for different depths of same grade of sand, and with rates of flow from 250,000 to 5,000,000 gallons per acre per day have been investigated.

Experiments on continuous filtration with dried Alumina and Polarite at rates of flow of 500,000 to 3,000,000 gallons per acre per day have been conducted. Experiments have been made with Pasteur and other filters and with the Anderson process, so called.

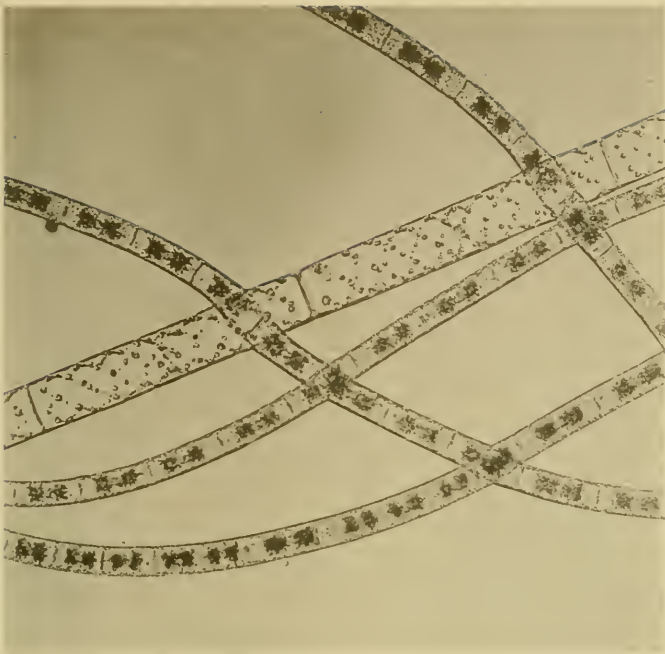
Experiments have been made on removal of color from water by exposure to sunlight and effect of storage of applied water and effluents in an open tank.

The filter-station has been in charge of Mr. William E. Foss, Assistant Engineer. The chemical analyses have been made under the direction of Dr. Thomas M. Drown.

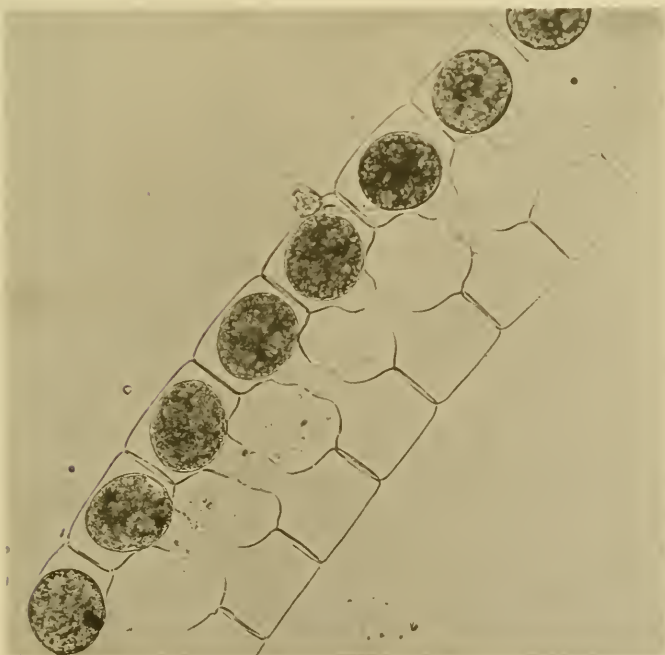
Mr. Frederick L. Hollis, Assistant, has made at my request an elaborate and valuable investigation into the colors of our waters with reference to the presence of iron, and his report is submitted herewith.

Briefly stated this examination shows that in the Boston waters, and in surface waters generally, the color is due, almost wholly, to carbonaceous matter, and not to iron.

During the period of stagnation the bottom layers at Lake Cochituate accumulate a considerable amount of iron in the ferrous state which oxidizes to the ferric condition as soon as brought to the surface and exposed to the air. The effect of this action is to increase the color rapidly, and within a few hours it reaches maximum. The amount of the color



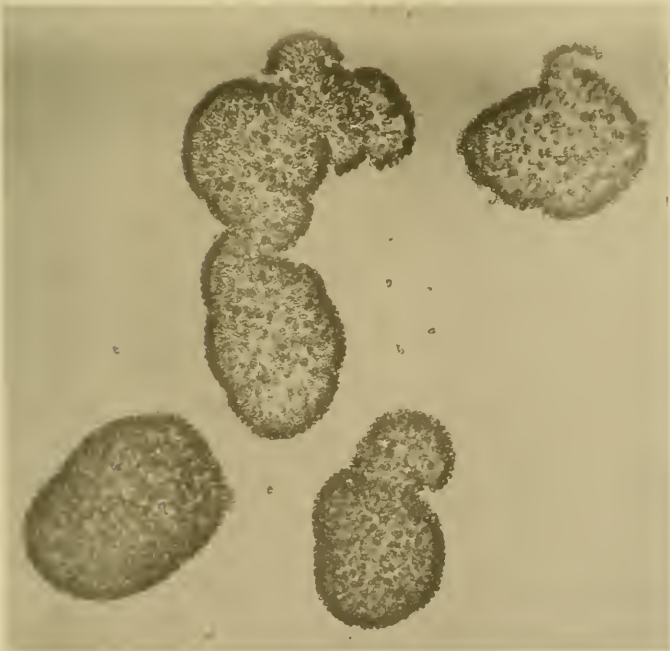
ZYGNEMA AND SPIROGYRA (CHLOROPHYCEÆ) X 125.



CONJUGATING FORM OF SPIROGYRA X 285.



ANABÆNA (CYANOPHYCEÆ) X 285.



COELOSPHAERIUM (CYANOPHYCEÆ) X 285.

corresponds to the amount of iron and manganese present. This accumulation of iron in the deep holes of the lake is caused by the gradual deposition of ferric hydrate from the surface layers, which in presence of organic matter undergoing decomposition, and owing to the absence of oxygen, becomes reduced again to the ferrous or colorless condition.

In closing I desire to call attention to the excellent work performed by my assistants in their several departments.

A great deal of time has been devoted to investigating the capacities of the present sources of supply and the effect of possible developments in the near future. Tables have been prepared showing the yields of different portions of the water-shed, and the yields with varying storage developments, and numerous studies and plans have been made for the drainage of the Cedar-swamp territory and the construction of two new basins, one of them involving the raising of the Boston & Albany Railroad.

QUALITY OF THE WATER.

The quality of the water has on the whole been very good throughout the year.

The following tables give, first, the average condition of the water as delivered at a tap in Boston during the year 1892; and secondly, means of monthly analyses in 1892 of different portions of the supply. They afford a ready means of comparison with the condition of the water as given in the last annual report.

The succeeding tables contain the average results of biological examinations made during the past year, together with temperature observations and rain-fall records.

Very truly yours,

DESMOND FITZGERALD,
Resident Engineer and Superintendent.

Table I.—Tap Water, Boston, 1892.
PARTS IN 100,000.

LOCALITY.	Color.	RESIDUE ON EVAPORATION.			Chlorine.	NITROGEN.						Oxygen Consumed.	Hardness.	REMARKS.
		Total.	Loss on Ignition.	Fixed.		Albuminoid Ammonia.		Free Ammonia.	As Nitrates.	As Nitrates.				
Service-pipe, Mass. Inst. of Technology.	0.37	4.69	1.67	3.02	.41	.0168	Unfiltered.	.0138	.0007	.0001	.0210	. . .	1.78	Means of monthly analyses.

TABLE II.
Means of Monthly Analyses, January 1 to December 31, 1892, by Dr. Thomas M. Drown.
 PARTS PER 100,000.

Source.	Color.	Residue on Evaporation.			Chlorine.	Nitrogen.					Oxygen Consumed.	Hardness.	Remarks.
		Total.	Loss on Ignition.			Albuminoid Ammonia.		Free Ammonia.	As Nitrates.	As Nitrates.			
			Fixed.	Unfixed.		Unfiltered.	Filtered.						
Sudbury River, Upper end Res. No. 2, samples collected 1 ft. beneath surface	1.00	4.71	2.08	2.63	.28	.0247	.0214	.0006	.0001	.0099	. . .	1.31	
Reservoir No. 2, near gate-house, samples collected 8 ft. beneath surface	0.89	4.35	1.92	2.43	.29	.0229	.0192	.0004	.0000½	.0082	. . .	1.28	
Stony Brook, Upper end Res. No. 3, samples collected 1 ft. beneath surface.	0.96	6.18	2.34	3.84	.49	.0291	.0252	.0015	.0002	.0202	. . .	1.95	
Reservoir No. 3, near gate house, samples collected 8 ft. beneath surface	0.72	5.17	1.98	3.19	.39	.0254	.0219	.0024	.0001	.0211	. . .	1.78	
Cold Spring Brook, at head of Res. No. 4, samples collected 1 ft. beneath surface	1.44	5.15	2.57	2.57	.25	.0308	.0266	.0003	.0000½	.0068	. . .	1.23	
Reservoir No. 4, near gate house, samples collected 1 ft. beneath surface	0.64	3.60	1.52	2.08	.23	.0200	.0168	.0002	.0001	.0038	. . .	1.15	
Lake Cochituate, gate-house	0.14	4.61	1.35	3.26	.48	.0168	.0133	.0018	.0001	.0132	. . .	2.06	
Service-pipe, Mass. Inst. Tech., Boston	0.37	4.69	1.67	3.02	.41	.0168	.0138	.0007	.0001	.0210	. . .	1.78	

TABLE III.
Lake Cochrane, 1892.

MONTH.	ORGANISMS.				AMORPHOUS.				REMARKS.
	Sur.	Mid.	Bot.	Mean.	Sur.	Mid.	Bot.	Mean.	
January	750	1,128	1,561	1,146	223	261	504	329	{ Diatoms. { Infusoria. { Asterionella. { Melosira.
February	267	616	686	523	76	198	274	183	{ Diatoms. { Asterionella. { Melosira.
March	262	477	757	499	172	205	801	392	{ Diatoms. { Asterionella. { Melosira.
April	665	777	897	779	243	335	329	302	{ Diatoms. { Infusoria. { Melosira. { Synedra.
May	945	804	1,037	929	141	175	418	245	{ Diatoms. { Infusoria. { Synedra. { Asterionella. { Stephanodiscus.
June	492	322	313	376	152	228	745	375	{ Diatoms. { Infusoria. { Stephanodiscus. { Asterionella. { Tabellaria.
July	596	160	358	371	265	140	2,265	890	{ Chlorophyceae. { Diatoms. { Cyanophyceae.
August	291	213	332	279	137	293	2,148	859	{ Chlorophyceae. { Cyanophyceae. { Diatoms (Melosira).
September	143	108	214	155	127	391	1,734	750	{ Cyanophyceae. { Diatoms. { Asterionella.
October	547	395	217	386	137	239	1,126	501	{ Diatoms. { Cyanophyceae. { Melosira.
November	529	533	341	468	291	285	572	383	{ Asterionella. { Melosira. { Stephanodiscus.
December	788	801	803	797	170	192	212	191	{ Asterionella. { Melosira. { Stephanodiscus.
Mean	523	528	626	559	178	245	927	450	

Zoospores, Desmidiaceae, Infusoria, Rotifera present throughout the year.

TABLE III. — *Continued.*
Basin 2, 1892.

MONTH.	ORGANISMS.					AMORPHOUS.					REMARKS.
	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.	
January	32	48	38	39	33	183	297	227	236	119	Diatoms.
February	24	22	18	22	14	51	50	62	54	37	"
March	13	9	9	10	14	47	73	64	61	76	"
April	72	64	60	66	42	133	122	143	133	85	} Synedra, } Tabellaria.
May	243	195	184	207	115	349	355	357	354	227	" (Synedra).
June	254	225	149	209	116	301	284	506	304	241	"
July	286	256	190	244	123	473	433	851	586	278	" (Cyclotella).
August	487	517	530	511	653	483	579	558	540	582	} Chlorophyceae (Anabaena). } Chlorophyceae.
September	726	699	645	690	131	416	445	606	439	208	} Cyanophyceae (Anabaena). } Diatoms (Cyclotella).
October	364	273	299	312	196	404	274	414	334	494	Diatoms (Cyclotella).
November	654	688	584	642	106	524	484	538	515	256	"
December	60	72	38	57	18	145	196	185	175	118	"
Mean	268	256	229	251	130	292	299	376	323	227	

Zoospores, Infusoria, and Rotifera present throughout the year.

Table III.—Continued.
Basin 3, 1892.

MONTH.	ORGANISMS.					AMORPHOUS.					REMARKS.
	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.	
January	83	72	64	73	17	332	317	351	333	124	Diatoms.
February	23	17	20	20	15	110	77	100	96	31	"
March	8	12	15	12	12	89	84	159	111	35	"
April	267	234	256	252	139	201	147	140	163	121	"
May	787	735	801	774	178	281	277	517	358	199	{ Synedra. Tabelaria. Asterionella. Chlorophyceæ and Cyanophyceæ.
June	529	472	306	436	161	199	201	1,499	633	499	{ Diatoms (Tabelaria). Chlorophyceæ and Cyanophyceæ
July	525	656	274	485	182	261	372	2,605	1,079	326	{ Diatoms. } Cyclotella. Chlorophyceæ and Cyanophyceæ.
August	398	485	396	426	250	282	1,155	2,214	1,217	367	{ Cyanophyceæ. Chlorophyceæ. Diatoms. (Cyclotella).
September	598	419	517	511	328	354	386	666	469	388	{ Diatoms. Cyanophyceæ. Chlorophyceæ.
October	1,854	1,998	2,154	2,002	50	411	455	538	468	71	{ Diatoms. } Asterionella. Tabelaria. Chlorophyceæ.
November	678	690	645	671	24	382	362	388	377	220	{ Diatoms. } Asterionella. Tabelaria.
December	423	490	326	413	19	187	223	201	204	94	{ Diatoms (Tabelaria). Chlorophyceæ.
Mean	514	523	481	506	115	257	338	781	459	206	

Zoopoeas, Desmidiæ, Infusoria, and Rotifera are found in small numbers throughout the year.

TABLE III. — *Continued.*
Basin 4, 1892.

Month.	ORGANISMS.					AMORPHOUS.					REMARKS.
	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.	
January	182	326	290	206	20	133	204	181	173	65	Diatoms, Chlorophyceae.
February	53	70	47	57	16	30	39	40	36	19	"
March	11	13	12	12	21	35	56	57	49	42	"
April	71	59	60	63	26	105	135	151	130	86	"
May	225	206	127	186	29	122	135	136	131	57	{ Cyclotella. { Synedra. { Cyclotella. { Synedra.
June	496	363	340	400	59	176	197	155	176	105	"
July	99	67	64	77	14	144	131	174	150	119	"
August	126	49	43	73	27	220	194	185	199	89	{ Chlorophyceae. { Diatoms. { Chlorophyceae.
November	188	141	129	153	24	179	170	176	175	65	{ Diatoms (Cyclotella). { Chlorophyceae.
October	406	463	435	435	12	531	734	493	586	50	"
November	907	986	855	916	19	455	390	397	414	57	Diatoms (Cyclotella).
December	459	473	422	451	10	244	225	281	250	52	"
Mean	269	268	235	257	23	198	218	202	206	67	"

Zoospores often present.

TABLE III. — *Concluded.*

MONTH.	CHESTNUT-HILL RESERVOIR.					BROOKLINE RESERVOIR.			TAPS IN CITY.			
	Organisms.			Amorphous.		Effluent G. H.		Amorphous.	Organisms.		Amorphous.	
	Effluent G. H.	Sudbury G. H.	Cochituate G. H.	Effluent G. H.	Sudbury G. H.	Cochituate G. H.	Organisms.		Park Square.	Mattapan.	Park Square.	Mattapan.
January	446	43	861	250	283	193	419	232	381	162	160	226
February	277	78	505	157	193	231	349	165	235	170	66	125
March	194	25	277	147	159	135	171	101	155	109	94	149
April	309	179	698	112	262	137	302	114	295	257	136	140
May	383	180	924	183	246	241	337	164	322	114	241	170
June	437	174	617	141	192	158	423	177	334	73	188	250
July	470	171	535	189	284	174	408	178	347	134	214	162
August	292	296	262	272	381	144	286	267	133	59	87	52
September	258	659	124	195	415	116	211	201	146	63	203	76
October	238	335	465	157	409	104	203	120	224	64	181	63
November	229	467	532	204	502	104	301	173	194	88	141	90
December	157	166	650	217	182	209	181	159	121	91	83	79
Mean	308	248	538	185	292	170	171	171	241	115	149	132

TABLE IV.
Temperatures¹ for 1892 (Fahrenheit).

MONTH.	LAKE OCHITUATE.			BASIN 2.			BASIN 3.			BASIN 4.		
	Sur.	Mid.	Bot.	Sur.	Mid.	Bot.	Sur.	Mid.	Bot.	Sur.	Mid.	Bot.
January	34.8	36.4	36.9	34.1	34.7	35.4	33.6	34.1	34.9	34.3	36.0	36.6
February	34.5	37.5	38.3	33.8	35.1	37.7	34.1	35.9	37.3	35.0	36.7	37.8
March	35.8	37.2	38.1	34.0	35.1	36.9	34.0	35.8	37.6	36.2	37.8	39.0
April	44.7	43.3	42.9	49.1	48.7	48.2	47.3	47.1	46.9	46.2	44.9	44.0
May	56.9	49.1	44.4	53.3	57.1	56.6	56.8	56.1	55.3	56.6	54.1	51.2
June	73.8	51.6	44.1	74.0	71.9	65.1	73.0	70.5	60.7	74.3	61.9	54.6
July	75.2	51.4	44.1	77.6	74.8	69.9	76.6	73.9	67.5	77.1	67.0	55.1
August	75.3	50.8	44.1	74.2	73.5	72.6	73.9	72.9	67.6	74.0	66.8	54.2
September	67.0	50.7	44.2	68.3	67.6	66.9	67.6	67.2	66.4	66.8	63.1	53.0
October	56.6	51.8	44.3	55.9	55.7	55.6	55.6	55.4	55.4	55.1	55.2	55.9
November	47.7	47.3	45.0	42.1	42.5	42.6	42.7	42.8	42.8	44.3	44.6	44.6
December	35.0	37.0	38.3	34.2	34.9	35.3	34.4	35.1	35.7	37.3	38.0	38.3
Mean	53.1	45.3	42.0	53.0	52.6	51.9	52.5	52.2	50.7	53.1	50.5	46.9

¹ Basin on one observation per week, 10 A.M.

TABLE IV.

Temperatures for 1892 (Fahrenheit). — *Concluded.*

MONTH.	CHESTNUT-HILL RESERVOIR GATE-HOUSES.			CHESTNUT-HILL RESERVOIR.			BROOKLINE RESER- VOIR GATE-HOUSE.	PARK SQUARE. TAP.	MATTAPAN. TAP.
	Sudbury.	Cochituate.	Effluent.	Surface.	Middle.	Bottom.			
January	35.3	37.5	35.2	34.5	36.0	36.8	36.7	38.1	43.4
February	35.8	37.8	36.6	34.5	35.5	36.3	36.8	38.8	40.3
March	35.3	37.9	35.9	37.5	37.6	37.8	36.2	36.8	38.9
April	48.2	45.2	47.0	48.1	47.1	47.3	46.9	46.8	43.6
May	56.5	54.5	55.8	57.5	56.2	55.8	55.7	55.1	49.1
June	71.5	69.4	69.5	71.3	69.2	57.5	70.1	69.0	57.2
July	74.8	73.4	73.0	76.6	72.8	59.6	73.7	73.1	62.9
August	73.9	74.8	74.3	75.3	72.2	62.1	74.6	72.9	64.5
September	67.8	67.5	68.2	67.9	67.3	64.7	67.9	66.7	62.3
October	56.8	57.8	57.2	57.3	57.4	67.3	56.9	57.3	57.4
November	44.5	48.3	46.1	46.3	45.7	46.3	45.6	47.1	50.8
December	36.9	40.4	35.4	35.8	35.9	36.1	36.2	37.9	43.7
Mean	53.1	53.7	52.9	53.6	52.7	49.8	53.1	53.3	51.2

The above figures are based on weekly observations.

TABLE V.
Colors, 1892. (Nessler Scale.)

MONTH.	LAKE OCHUTUATE.					BASIN 2.					BASIN 3.					BASIN 4.				
	Sur.	Mid.	Bot.	Mean.	Influ-ent.	Sur.	Mid.	Bot.	Mean.	Influ-ent.	Sur.	Mid.	Bot.	Mean.	Influ-ent.	Sur.	Mid.	Bot.	Mean.	Influ-ent.
January	.25	.20	.31	.29	.50	1.05	1.03	.99	1.02	1.09	.80	.80	.80	.80	.82	.61	.55	.54	.57	1.42
February	.28	.27	.38	.31	.64	.70	.81	.81	.80	.81	.73	.77	.79	.76	.70	.69	.66	.64	.66	.93
March	.29	.30	.68	.42	.68	.81	.70	.78	.79	.86	.76	.78	.77	.77	.80	.71	.69	.68	.69	.96
April	.32	.33	.37	.34	.72	.82	.83	.82	.83	.95	.71	.72	.71	.71	1.05	.71	.70	.70	.70	1.05
May	.27	.26	.32	.28	1.22	.96	.98	.98	.97	1.22	.85	.86	.89	.87	1.29	.70	.69	.66	.68	1.43
June	.27	.22	.81	.43	.83	1.36	1.41	1.39	1.39	1.46	1.20	1.19	1.33	1.24	1.56	.85	.83	.76	.81	2.21
July	.27	.24	1.28	.60	.48	1.10	1.13	1.33	1.19	1.03	1.05	1.05	1.63	1.24	1.14	.82	.85	.75	.81	1.75
August	.19	.22	2.03	.81	.48	.88	.88	.87	.88	.98	.85	1.05	1.09	1.30	.86	.67	.69	.67	.68	1.23
September	.12	.22	2.38	.91	.59	.92	.92	.96	.93	1.05	.86	.86	.93	.88	.93	.65	.67	.67	.66	1.98
October	.12	.17	2.48	.92	.43	.86	.86	.86	.86	.88	.75	.75	.83	.78	.72	.76	.77	.79	.77	1.08
November	.23	.30	.87	.48	.82	.89	.89	.90	.89	1.36	.73	.73	.74	.73	1.06	.80	.81	.82	.81	1.52
December	.28	.28	.32	.29	.48	1.64	1.61	1.61	1.62	1.53	.98	.98	1.07	1.01	1.35	.99	.99	.99	.99	1.66
Mean	.25	.26	1.02	.51	.66	1.61	1.01	1.02	1.01	1.10	.86	.88	1.04	.92	1.02	.75	.74	.72	.74	1.43

¹ Estimate based on colors taken in Beaver dam, Course, Pegam, and Snake brooks, and disregarding spring-water.

TABLE V. — Colors, 1892. — *Concluded.*

MONTH.	CHESTNUT-HILL RESERVOIR GATE-HOUSES.			CHESTNUT-HILL RESERVOIR.			BROOKLINE RESERVOIR GATE-HOUSE.	PARK SQUARE TAP.	MATAPAN TAP.
	Sudbury.	Cochituate.	Effluent.	Surface.	Middle.	Bottom.			
January	.37	.21	.45	.44	.44	.45	.46	.48	.48
February	.74	.25	.50	.57	.54	.52	.51	.52	.47
March	.77	.27	.59	.57	.58	.61	.60	.57	.52
April	.76	.25	.46	.45	.45	.45	.49	.46	.42
May	.58	.24	.42	.39	.40	.39	.42	.40	.27
June	.87	.22	.40	.40	.42	.35	.45	.45	.39
July	.94	.24	.59	.57	.57	.32	.60	.57	.55
August	.78	.17	.52	.52	.51	.78	.52	.49	.45
September	.77	.12	.42	.44	.45	.66	.41	.47	.34
October	.79	.10	.49	.49	.49	.50	.43	.46	.35
November	.85	.19	.45	.45	.45	.45	.43	.47	.37
December	1.37	.26	.92	.93	.92	.92	.94	.92	.76
Mean	.80	.21	.52	.52	.52	.53	.52	.52	.45

Bacteria, 1892.

MONTH.	CHESTNUT-HILL RESERVOIR GATE-HOUSES.			CHESTNUT-HILL RESERVOIR.			BROOKLINE RESER- VOIR GATE-HOUSE.	PARK SQUARE TAP.	MATTAPAN TAP.
	Sudbury.	Cochituate.	Effluent.	Surface.	Middle.	Bottom.			
January	162	97	108	. . .	. . .	. . .	100	113	92
February	315	61	136	95	78	97	110	86	75
March	644	99	237	132	104	301	142	120	55
April	252	67	120	48	49	129	98	65	65
May	70	190	227	74	409	512	48	67	70
June	170	583	204	24	973	1,141	45	61	133
July	326	544	379	35	851	991	48	61	161
August	83	93	33	32	634	748	68	61	91
September	158	127	365	54	1,421	570	95	102	58
October	119	192	253	98	522	376	85	71	46
November	247	612	291	180	516	544	165	63	36
December	112	64	101	36	129	158	53	39	29
Mean	222	227	205	73	517	506	88	76	76

TABLE VI.
Expenditures on Maintenance, of Western Division, for year 1892-3.

Drafts.	Western Division.	Dams.	Snubury Aqueduct.	Cochituate Aqueduct.	Lake Cochituate.	Chestnut Hill Reservoir.	Chestnut Hill Driveway.	Brookline Reservoir.	Fishers Hill Reservoir.	Biological Department.	Inspection Department.	Filtration.	Lining Tunnel.	Surveys.	Totals.
February 1, 1892	\$418 07	\$2,085 36	\$143 13	\$85 10	\$103 34	\$3,135 37	\$137 55	\$43 70	\$211 70	\$135 92	\$44 08	\$447 93	\$161 84	\$22 00	\$7,575 69
March 1, "	1,044 71	2,363 08	230 39	75 50	287 59	1,169 78	1,025 60	57 25	55 75	339 99	494 39	570 28	2,701 67	456 88	10,863 86
April 1, "	1,112 15	1,311 95	206 60	94 25	146 37	1,819 11	1,052 08	103 00	92 20	422 18	412 14	543 11	3,526 03	340 59	11,181 76
May 1, "	1,120 15	1,700 05	278 45	101 75	315 51	1,459 53	810 38	102 30	102 85	361 82	447 52	621 59	2,258 69	...	9,680 50
June 1, "	1,121 21	1,114 11	428 49	158 80	311 98	1,612 23	1,198 10	54 45	85 85	387 79	460 56	608 18	297 32	...	7,839 07
July 1, "	1,032 32	576 12	360 82	159 50	271 50	888 61	1,278 24	40 07	71 08	377 44	427 70	698 16	...	...	6,181 56
August 1, "	816 87	500 20	397 80	126 00	316 32	1,231 08	992 44	181 76	253 75	436 44	426 81	707 35	...	...	6,386 82
September 1, "	717 11	590 21	390 85	170 25	438 83	916 52	1,260 74	77 50	81 50	335 43	443 08	606 16	...	...	5,998 18
October 1, "	649 36	499 56	418 76	220 25	354 93	1,162 66	941 81	55 25	63 75	325 26	360 01	492 59	...	...	5,544 19
November 1, "	696 99	438 45	337 06	221 75	219 03	1,296 12	872 20	231 92	174 61	367 36	440 23	805 21	...	...	6,100 93
December 1, "	726 12	452 09	309 26	400 25	219 11	1,058 61	926 97	65 05	56 00	344 29	520 61	495 45	...	...	5,57 81
January 1 & 31, 1893	1,661 44	893 18	608 05	1,068 59	404 94	2,727 70	1,568 95	180 25	223 50	741 20	763 50	1,161 66	...	...	12,065 96
Totals	\$11,116 50	\$12,524 36	\$4,139 66	\$2,381 99	\$3,389 45	\$18,477 32	\$12,065 06	\$1,192 50	\$1,472 54	\$4,566 12	\$5,641 28	\$7,760 58	\$8,945 55	\$819 47	\$94,992 33

Table of Rainfall at Chestnut-Hill Reservoir for Year ending
December 31, 1892.

DATE.	Inches.	Snow or Rain.	Duration.	DATE.	Inches.	Snow or Rain.	Duration.
Jan. 2	1.15	Rain.	2.50 p.m. to	Apr. 21	0.48	Rain.	4.00 p.m. to
" 3			12.30 a.m.	" 22			12.30 a.m.
" 6	0.50	Snow and Rain.	9.30 a.m. to 11.30 p.m.	" 22	0.21	"	3.30 p.m. to
" 12	1.30	Rain.	4.00 a.m. to	" 23			6.00 a.m.
" 13			11.00 a.m.	" 29	0.06	"	12.30 p.m. to 5.50 p.m.
" 14	0.55	Snow and Rain.	6.30 p.m. to	Total.	0.75		
" 15			5.00 p.m.				
" 18	0.79	Rain and Snow.	3.50 p.m. to	May 1	0.07	Rain.	5.20 p.m. to 11.00 p.m.
" 19			5.30 a.m.	" 2	0.30	"	12.45 p.m. to 10.30 p.m.
" 19	0.16	Snow.	12.10 p.m. to 11.30 p.m.	" 4	0.42	"	1.45 a.m. to 6.00 a.m.
Total.	4.45			" 11	0.60	"	9.00 a.m. to 6.00 p.m.
				" 15	1.02	"	2.00 a.m. to 6.06 p.m.
Feb. 2	0.96	Rain and Snow.	3.00 p.m. to	" 19	1.12	"	8.30 p.m. to
" 3			4.15 p.m.	" 20			11.50 a.m.
" 7	0.30	Snow and Rain.	4.30 p.m. to	" 21	1.34	"	6.00 a.m. to 11.30 p.m.
" 8			5.00 a.m.	" 22	0.72	"	10.30 p.m. to
" 11	1.35	Snow.	5.30 a.m. to	" 23			10.00 a.m.
" 12			1.30 a.m.	" 26	0.36	"	12.15 a.m. to 8.00 a.m.
" 14	0.07	Rain.	9.00 p.m. to	" 27	0.13	"	9.40 a.m. to 2.00 p.m.
" 15			4.00 a.m.	Total.	6.08		
" 25	0.10	Showers and mist.	6.30 p.m. to 10.00 p.m.				
Total.	2.78			June 3	0.27	Rain.	8.30 a.m. to 12.30 p.m.
				" 6	0.32	"	4.15 p.m. to 4.50 p.m.
Mar. 1	1.06	Snow.	11.15 a.m. to	" 8	0.29	"	11.00 p.m. to
" 2			5.00 p.m.	" 9			7.00 p.m.
" 3	0.70	Rain.	3.15 p.m. to 11.45 p.m.	" 14	0.13	"	7.30 p.m. to 10.30 p.m.
" 8			7.00 p.m. to 11.55 p.m.	" 17	1.18	"	3.40 p.m. to 5.30 p.m.
" 10	0.43	"	2.00 a.m. to	" 25	0.44	"	4.00 a.m. to 8.00 a.m.
" 18	1.06	Snow.	9.30 a.m.	" 25	0.43	"	3.50 p.m. to 5.00 p.m.
" 19			12.20 a.m. to 7.00 p.m.	" 26	0.41	"	5.35 p.m. to 11.45 p.m.
" 23	0.70	Snow and Rain.		" 28	0.42	"	1.00 a.m. to 4.30 a.m.
Total.	3.95			Total.	3.89		

Table of Rainfall at Chestnut-Hill Reservoir. — *Concluded.*

DATE.	Inches.	Snow or Rain.	Duration.	DATE.	Inches.	Snow or Rain.	Duration.
July 1	0.19	Rain.	10.00 a.m. to 4.30 p.m.	Oct. 9	0.07	Rain.	6.00 a.m. to 8.00 a.m.
" 3	0.14	"	7.30 a.m. to 8.30 a.m.	" 16	0.38	"	7.00 a.m. to 3.00 p.m.
" 3	0.74	"	5.35 p.m. to 11.00 p.m.	" 26	0.12	"	6.30 a.m. to 7.30 a.m.
" 9	0.04	"	6.30 p.m. to 9.00 p.m.	" 29	0.10	"	9.00 a.m. to 4.45 p.m.
" 16	0.16	"	3.00 a.m. to 6.30 a.m.				
" 25	0.44	"	2.10 a.m. to 3.00 a.m.	Total.	2.39		
" 29	0.31	"	8.40 p.m. to 11.15 p.m.				
" 31	1.33	"	12.10 p.m. to midnight.	Nov. 2	0.61	Rain.	1.30 a.m. to
Total.	3.35			" 3			3.30 p.m.
Aug. 1	0.06	Rain.	Midnight, July 31, to 11.30 a.m.	" 5	0.13	Snow.	6.30 a.m. to 3.30 p.m.
" 3	0.34	"	3.00 a.m. to 9.00 a.m.	" 7	0.09	Showers.	7.30 p.m. to
" 5	0.25	"	5.50 p.m. to 7.00 p.m.	" 8			6.30 a.m.
" 12	2.19	"	12.10 a.m. to 8.30 a.m.	" 9	1.86	Snow and Rain.	8.45 p.m. to
" 13	0.31	"	1.30 a.m. to 3.00 a.m.	" 10			3.30 p.m.
" 25	2.46	"	3.45 p.m. to	" 15	1.71	Rain.	9.15 a.m. to
" 26				" 16			11.45 a.m.
" 27			6.00 a.m.	" 18	0.28	"	5.30 p.m. to 10.00 p.m.
" 27	0.05	Mist.	8.00 a.m. to	" 28	0.18	Snow and Rain.	9.05 a.m. to 6.00 p.m.
" 28			1.00 a.m.	" 29	0.40	Snow.	9.45 a.m. to
" 31	0.26	Rain.	7.00 p.m. to 10.45 p.m.	" 30			6.00 p.m.
Total.	5.92			Total.	5.26		
Sept. 14	1.62	Rain.	5.30 a.m. to 10.30 p.m.	Dec. 8	0.82	Rain.	9.20 a.m. to
" 24	0.12	"	2.00 p.m. to 3.30 p.m.	" 9			2.00 a.m.
" 26	0.42	"	5.45 a.m. to 11.15 a.m.	" 14	0.32	Snow and Rain.	5.00 a.m. to 7.00 p.m.
Total.	2.16			" 20	0.09	Snow.	5.30 a.m. to 12.15 p.m.
Oct. 3	1.72	Rain.	2.00 p.m. to	" 25	0.06	"	3.30 p.m. to 7.30 p.m.
" 4				Total.	1.29		
" 5			11.30 a.m.	Total Rainfall for year 1892, 42.27 inches.			

AN INVESTIGATION OF THE CAUSE OF THE
COLOR OF NATURAL WATER.

BY FREDERICK S. HOLLIS.

The cause of the color of natural water is attributed by all who have written upon the subject, as far as I am able to ascertain, to the organic impurities.

Tidy,¹ in his article on the color of water, says: "The color of a surface water is caused by the peaty or vegetable impurities, and the color varies with the condition of the vegetable matter present." He finds that the color imparted by very recently formed peaty matter is yellowish green, that by recent peat a brownish olive green, while that obtained from old peat is a true brown or coffee color entirely free from the olive tint.

Dr. Drown,² in his article on "The Odor and Color of Surface Waters," comes to the same conclusion. Artificial colored waters were prepared by him by extracting leaves in distilled water, and it was shown that for the same color the amount of albuminoid ammonia was less with subsequent extractions.

	Color.	Alb. am.
First infusion of leaves	.8	.0494
Subsequent infusion of same leaves	.8	.0178
Infusion of old leaves	.9	.0072

My own work, while confirming the conclusion that the coloring matter may be derived from such vegetable matter as leaves, seems to justify the conclusion that the color of a natural water is, in some cases at least, dependent to a large extent on the iron and manganese contents in combination with the extractive organic matter.

In a study of the cause of the color of water are found the rather different problems of :

I. The cause of the increase of color, during warm weather, of water from the bottom of the deeper ponds, and

II. The cause of the more permanent color of surface waters, as those from shallow ponds and swamps and from brooks and rivers.

I.

The cause of the color, during warm weather, of water from the bottom of the deeper ponds, and its further increase on exposure to light and air.

¹ Jour. Chem. Soc. 1880, p. 293.

² Technology Quarterly 1888, p. 256.

During the summer of 1890, weekly samples of water were taken from different depths of Lake Cochituate and the different storage basins of the Boston Water-Works, for biological examination, and the temperature and color of these samples were also noted.

A conspicuous feature of the samples collected at the bottom of some of these sources, notably Lake Cochituate and Basin 3, was their darker color than samples collected near the surface, and the fact that this color increased still further on exposure to light and air, so that on reaching the laboratory some hours later the color was frequently found to be three times that on collection.

At the request of Mr. Desmond FitzGerald, of the Boston Water Works, I undertook a study of the water from the deeper layers of these sources with reference to their higher color.

The following tables from the reports of the biological work referred to above, show the gradual increase of color at the bottom of the three sources to which I confined my work :

Lake Cochituate. — Depth, 60-65 feet.

1890.	SURFACE.		MID-DEPTH.		BOTTOM.	
	Temp.	Color.	Temp.	Color.	Temp.	Color.
August 5	78.5° F.	.10	50.0° F.	.20	45.0° F.	.80
“ 11	72.2	.10	50.0	.20	45.0	2.80
“ 19	72.9	.15	51.0	.30	45.0	3.80
“ 26	70.0	.15	49.0	.30	44.8	2.80
September 3	70.4	.10	49.0	.30	45.0	2.30
“ 9	70.5	.10	49.0	.30	44.8	2.60
“ 16	163 amorphous mat., no crenothrix.		145 amorphous mat., no crenothrix.		753 amorphous mat., much crenothrix.	
“ 20	105 amorphous mat., no crenothrix.		164 amorphous mat., no crenothrix.		940 amorphous mat., some crenothrix.	

Basin 3, Framingham. — Depth, about 20 feet.

1890.	SURFACE.		MID-DEPTH.		BOTTOM.		UPPER END.	
	Temp.	Color.	Temp.	Color.	Temp.	Color.	Temp.	Color.
August 4	79.2° F.	.50	73.8° F.	.50	66.3° F.	.70	78.5	.40
“ 11		.60						.70
“ 18	73.2	.80	72.8	.90	65.6	1.30	72.1	.70
“ 25	70.9	.80	70.0	.90	65.7	1.00	68.4	.90
September 2 ¹ . . .	70.1	.80	69.7	.80	69.5	.70	67.8	.60
“ 8	71.0	.60	70.9	.62	68.9	.80	70.1	.50

¹ A heavy wind during this interval mixed the water from all depths, causing a uniform color.

Basin 4, Ashland. — Depth, 30-35 feet.

1890.	SURFACE.		MID-DEPTH.		BOTTOM.		UPPER END.	
	Temp.	Color.	Temp.	Color.	Temp.	Color.	Temp.	Color.
August 5	78.8	.50	66.0	.50	54.3	.50	79.5	.45
“ 13	72.5	.35	65.5	.50	54.0	.60	70.3	.40
“ 18	72.3	.40	68.8	.50	53.8	.80	69.3	.50
“ 26	70.3	.50	70.2	.45	53.8	.80	69.4	.60
September 3	70.8	.40	65.7	.40	54.0	.70	68.2	.40
“ 9	71.5	.40	64.8	.45	53.8	.70	69.3	.40

None of the samples from the bottom of this reservoir darkened more than slightly on exposure.

Amorphous matter and crenothrix not abundant at the bottom.

The overturn of the water in Basin 3, due to the wind-storm noted in the tables, prevented its further study during that summer, but the water of Lake Cochituate and Basin 4, owing to their greater depth, was not disturbed at the bottom, and the study of the water from these sources was commenced immediately.

LAKE COCHITUATE.

On September 28, 1890, samples were taken for chemical analysis at the surface and at depths of 15, 30, 40, 50, and 60 feet, and the amount of oxygen held dissolved in the water at these depths was determined.

The surface water was found to be well aerated, containing 96.9 % of the amount of oxygen necessary for its saturation

at the observed temperature. The amount of oxygen so held decreased to 12.2% of saturation at a depth of 40 feet, while below this depth the water was completely deoxidized, showing the stagnation of the water below the depth to which it is kept in circulation by the action of the wind.

The color of the water of these bottom layers was much darker than at the surface and increased on exposure. The chemical analysis of the samples from these depths showed corresponding variations in the water between the surface and bottom. The large amount of free ammonia and of oxidizable carbonaceous matter in solution as revealed by the test of oxygen consumed, together with a sharp, disagreeable odor in water from the bottom layers, showed the presence of a considerable amount of organic matter undergoing decomposition.

These conditions are similar to those observed by Dr. Drown for Jamaica pond,¹ and later, for various ponds² and reservoirs in the State. A similar series for chemical analysis and determination of iron, which gave similar results, was taken the last of October, and during the following year chemical analyses were made monthly of water from the surface and bottom layer, from April to October, inclusive, together with two determinations of the amount of dissolved oxygen at different depths, made during August and September, and a chemical analysis was made of water from the bottom on the last of October of the second year following.

These results are given on the following analysis sheet :

BASIN 3—FRAMINGHAM.

Basin 3 differs from Lake Cochituate in that it is only about 20 feet deep, and in the more varied composition of its water, which makes it more liable to change from local conditions.

During 1891, chemical analyses and determinations of iron and manganese were made monthly, from April to September, inclusive, of water from surface and bottom of Basin 3, and determinations of the amount of dissolved oxygen at different layers during August and September. The results while confirming in a general way those obtained from Lake Cochituate, where the conditions remain constant for the entire summer, have not the same value. They are given on the following analysis sheet.

¹ Special Report of the Massachusetts State Board of Health (Examination of Water Supplies), 1890, p. 662.

² On the Amount of Dissolved Oxygen contained in Waters of Ponds and Reservoirs at different depths.— Report of the Massachusetts State Board of Health, 1891, p. 373.

WATER ANALYSIS. BOSTON WATER-WORKS.—LAKE COCHITUATE.

Parts in 100,000.

LOCALITY.	DATE OF		COLOR.		RESIDUE ON EVAPORATION.			NITROGEN.					Oxygen Consumed.	Hardness.	Iron.	Manganese.	Silica.	Dissolved Oxygen.	Temperature.			
	Collection.	Examination.	On Collection.	After Exposure.	Total.	Loss on Igni- tion.	Fixed.	CHLORINE.	ALBUMINOID AMMONIA.		Free Ammonia.	As Nitrates.								As Nitrites.		
									Unfiltered.	Filtered												
Lake Cochituate.																						
Surface	1890. September 18 . . .	1890. September 19 . . .	.22	.22	5.10	2.35	2.75	.44	.0152		.0004	.0003	.0050	.41	2.22			96.99	69.8° F.			
15 feet	" 18	" 19	.24	.23	5.80	2.55	3.25	.44	.0166		.0004	.0003	.0050	.46	2.34			88.3	69.8			
30 "	" 18	" 19	.42	.35	5.00	2.20	3.30	.46	.0158		.0008	.0003	.0270	.50	2.35			20.4	50.0			
40 "	" 18	" 19	.44	.38	5.45	2.40	3.05	.46	.0154		.0030	.0003	.0250	.62	2.40			12.2	48.9			
50 "	" 18	" 19	.80	1.90	7.00	3.10	4.50	.47	.0216		0.484	.0003	.0070	1.02	2.70			0.0	45.8			
60 "	" 18	" 19	1.20	3.70	9.80	3.60	6.20	.47	.0274		.0680	.0003	.0060	1.18	2.73	1.134	.144	1.29	0.0	45.5		
15 "	October 31	November 1			6.05	1.55	4.50	.54	.0124	.0122	.0030	.0002	.0060	.47	2.20	.178	.08	.58				
35 "	" 31	" 1			5.60	1.40	4.20	.53	.0128	.0128	.0026	.0002	.0110	.48	2.47							
63 "	" 31	" 1			10.55	2.35	8.20	.52	.0392	.0250	1.400	.0003	.0020	1.22	8.49							
65 "	" 31	" 1			14.30	2.85	11.45	.50	.0402	.0272	1.640	.0002	.0030	1.56	3.51	1.800	.26	2.99				
Surface	1891. April 8	1891. April 9	.64	.48	4.85	2.35	2.50	.42						.50		.06	.04	.50				
Bottom	" 8	" 9	.50	.47	4.75	2.00	2.75							.63		.07	.05	.30				
Surface	June 6	June 8	.24	.20	4.20	1.15	3.05	.42	.0170	.0146	.0016	.0002	.0200	.48	1.74	.03	.05	.05				
Bottom	" 6	" 8	.36	.50	1.35	3.65	.42	.0190	.0160	.0224	.0002	.0002	.0210	.52	1.84	.16	.06	.44				
Surface	July 17	July 18	.20	.40	4.05	1.60	2.45	.36	.0174	.0148	.0004	.0002	.0120	.43	1.76	.06	.03					
Bottom	" 17	" 18	1.30	6.25	2.25	4.00	.34	.0218	.0170	.0430	.0004	.0080	.96	1.65	.50	.07						
Surface	August 19	August 21	.15	.15	4.00	2.45	2.15	.48	.0156	.0148	.0012	.0004	.0030	.44	1.80	.11	.04			79.15	75.2	
Bottom	" 19	" 21	1.00	5.20	9.05	3.90	5.15	.43	.0262	.0218	.0600	.0006	.0020	1.07	2.15	.97	.20			0.0	45.5	
Surface	September 28 . . .	September 29 . . .	.15	.12	4.70	1.15	3.55	.44	.0134	.0116	.0002	.0002	.0020	.34	1.82	.11	.04	.31	100.0	73.4		
Bottom	" 28	" 29	1.20	3.40	8.05	2.25	5.80	.42	.0244	.0186	.0736	.0005	.0020	1.07	1.98	.96	.21	.86			0.0	48.2
Bottom	October 23	October 27			4.00	9.85	3.40	6.45		.0352	.0250	.0880	.0003	.0000	1.12	2.20	1.32	.29				45.0
Bottom	1892. October 27	1892. October 27	.75	3.00	8.85	2.20	6.65		.0260	.0232	.0538	.0006	.0000	.70	2.80	.80	.24				45.0	
1 Bottom	" 23, '91	March 25, '92	Filtered .02	Unfiltered. 12.90	Unfiltered. 4.90	Unfiltered. 8.10			.0700	.0168	.0008	.0005	.0020	Unfiltered. 1.53	1.90							
				Filtered 6.25	Filtered 1.60	Filtered 4.65								Filtered .38								

1 Same as sample collected October 23, 1891, exposed to sunlight during 543 hours.

Dis. O.—September 18, 1890.
Temp. 21.0° C.

Surface	21.0
15 feet	28.3
30 "	10.0
40 "	9.4
50 "	7.6
60 "	7.5

96.94 Satn.

Dis. O.—August 16, 1891.
Temp. 24.0° C.

Surface	15.5
10 feet	12.5
20 "	12.5
30 "	10.0
40 "	5.5
50 "	5.5
60 "	8.0
57½ " bottom	7.5

sharp disagreeable odor.

Dis. O.—September 28, 1891.
Temp. 21.0° C.

Surface	21.0
10 feet	14.0
20 "	14.5
30 "	11.0
40 "	11.0
50 "	10.0
60 "	9.0

90.05 Satn.

WATER ANALYSES. BOSTON WATER-WORKS.—BASIN NO. 3.
Parts in 100,000.

LOCALITY.	DATE OF				COLOR.		RESIDUE OF EVAPORATION.				NITROGEN.					Oxygen Consumed.	Hardness.	Iron.	Manganese.	Silica.	Dissolved Oxygen.	Temperature.		
											Albuminoid Ammonia.	Free Ammonia.	As Nitrites.	As Nitrates.										
	Basin No.3.	Collection.	Examination.	On Taking.	After Exposure.	Total.	Loss on Igni- tion.	Fixed.	Chloride.	Unfil- tered.					Filtered									
Surface	April	1891.	8 . . .	April	1891.	9	.62	3.90	2.15	1.75	. . .	. . .	. . .	. . .	. . .	.62	. . .	.07	.03	.58				
Bottom	"		8 . . .	"		9	.60	3.75	1.30	2.45	. . .	. . .	. . .	. . .	. . .	.62	. . .	.68	.02	.91				
Surface	June		6 . . .	June		6	.68	4.75	1.39	3.45	.10	.0294	.0246	.0004	.0003	.0080	.69	1.56	.04	.03	.22			
Bottom	"		6 . . .	"		6	.75	4.95	1.40	3.55	.37	.0278	.0220	.0092	.0003	.0070	.75	1.63	.07	.08	.36			
Surface	July		17 . .	July		18	.60	5.25	2.45	2.80	.37	.0248	.0212	.0002	.0001	.0100	.72	1.59	.10	.04				
Bottom	"		17 . .	"		18	1.50	6.30	2.05	4.25	.37	.0310	.0232	.0370	.0002	.0060	1.22	2.00	.66	.12				
Surface	August		19 . .	August		21	3 days .35	6.25	2.40	3.85	.45	.0224	.0214	.0008	.0002	.0020	.65	1.55	.17	.03		85.88	76.2	
Bottom	"		19 . .	"		21	2.00 3.00	7.20	2.45	4.75	.44	.0310	.0250	.0496	.0004	.0020	1.20	1.96	.70	.16		0.0	63.5	
Surface ¹	September		28 . .	September		29	.50 .31	5.05	1.45	3.60	.45	.0240	.0190	.0004	.0001	.0020	.84	1.60	.09	.02	.24	90.7	79.7	
Bottom ¹	"		28 . .	"		29	nearly .80	5.60	1.95	3.65	.45	.0294	.0228	.0144	.0003	.0000	.92	1.60	.16	.06	.39	38.3	68.0	

¹Water in Basin 3 turned over by high wind.

Dis. O — August 20, 1891.

Surface	85.30
6 feet	85.06
12 "	58.97
14 "	0.00
15 "	0.00
17 "	0.00
19 "	0.00
21 "	0.00

Dis. O — October 1, 1891.

Surface	90.75
10 feet	73.8
14 "	65.9
18 "	38.3

* Strong wind, water mixed.

WATER ANALYSES. BOSTON WATER-WORKS.—BASIN NO. 4. **Parts in 100,000.**

LOCALITY.	DATE OF		COLOR.		RESIDUE ON EVAPORATION.			Chloride.	NITROGEN.				Oxygen Consumed.	Hardness.	Iron.	Manganese.	Silica.	Dissolved Oxygen.	Temperature.		
	Basin No. 4.	Collection.	Examination.	On Taking.	After Exposure.	Total.	Loss on Ignition.		Fixed.	ALBUMINOID AMMONIA.		Free Ammonia.								As Nitrites.	As Nitrates.
										Unfiltered.	Filtered.										
Surface	1890. September 25 . .	1890. September 26 . .	.50						.0188		.0004	.0002	.0050					92.2	64.9		
10 feet	" 25	" 26	.50						.0214		.0004	.0002	.0050					87.0	64.4		
20 "	" 25	" 26	.60						.0220		.0014	.0002	.0030					17.5	60.6		
Bottom, 29 feet	" 25	" 26	.80						.0210		.0028	.0002	.0020					7.2	54.1		
Surface	1891. April 8	1891. April 9	.69		3.30	1.35	1.95							.70		.07	.10	.69			
Bottom	" 8	" 9	.63		3.00	1.40	1.60							.70		.06	.08	.53			
Surface	June 6	June 6	.58		3.10	1.20	1.90	.20	.0202	.0182	.0002	.0001	.0050	.64	.87	.05	.02	.36			
Bottom	" 6	" 6	.62		3.05	.85	2.20	.19	.0150	.0140	.0032	.0002	.0040	.57	.79	.05	.04	.40			
Surface	July 17	July 18	.50		3.45	1.25	2.20	.21	.0208	.0182	.0004	.0001	.0090	.67	.44	.06	.02				
Bottom	" 17	" 18	.60		3.35	1.65	1.70	.20	.0142	.0136	.0002	.0001	.0060	.78	.30	.15	.06				
Surface	August 19	August 21	.40		3.65	1.80	1.85	.25	.0134	.0122	.0002	.0002	.0030	.73	1.14	.06	.03	84.50	75.2		
Bottom	" 19	" 21	.60	.55	3.20	1.45	1.75	.28	.0118	.0110	.0008	.0002	.0040	.68	1.22	.22	.06	15.10	55.4		
Surface	September 29	September 29	.30	.25	3.20	1.25	1.95	.24	.0162	.0150	.0006	.0000	.0020	.58	.54	.11	.04	52	87.7		
Bottom	" 29	" 29	.60	.50	3.25	1.05	2.20	.22	.0130	.0126	.0008	.0001	.0060	.53	.50	.11	.02	.31	3.6		

Dis. O — September 25, 1890.			
Surface	13.2°C.	92.0% satn.	
10 feet	18.0	87.0	
20 "	15.9	17.5	
29 "	12.3	7.2	

Dis. O — August 20, 1891.			
Surface	24.6°C.	84.50% satn.	
10 feet	22.0	84.42	
20 "	17.0	28.62	
30 "	12.5	27.42	
35 "	13.0	16.28	
37 "	13.0	15.10	

Dis. O — October 1, 1891.			
Surface	22°C.	87.7% satn.	
10 feet	21.5	84.2	
15 "	21.0	82.5	
20 "	15.0	8.7	
25 "	14.5	7.4	
31 "	12.0	3.6	

BASIN 4 — ASHLAND.

Basin 4 differs from the other two sources in that all the loam was removed from the ground forming the bottom of the reservoir, and samples of earth collected from the bottom at its deepest part show that it is still composed of clean, sandy material. The water that it receives from Cold Spring brook, although higher colored than that from Stony brook, is a normal surface water, uncontaminated except from vegetation. The determination of dissolved oxygen shows that at no time during the summers of 1890 and 1891 was the water from the bottom layers completely deoxidized.

The color of the water from these layers was generally less than twice as dark as at the surface and did not increase on exposure.

The foregoing analyses show, particularly by the tests of ammonia and oxygen consumed, — which are measures of the nitrogen and carbon, — the presence of a considerable amount of organic matter at the bottom of those ponds in which the darkening of the water was most noticeable. The ultimate end of these constituents of organic matter is nitric acid for the nitrogen and carbonic acid for the carbon.

If, however, there is only a limited amount of oxygen available to support this decomposition, which is a process of oxidation brought about mainly by the action of micro-organisms, the process is arrested when the oxygen is used up; and, in the case of water at the bottom of deep ponds, this process cannot be completed until the surface water cools to its point of greatest density in autumn and sinks to the bottom, carrying with it a fresh supply of oxygen. The absence of oxygen from the lower layers, and the fact that the constituents of the organic matter were found in a partially oxidized form, show that these were the conditions when the samples were taken. The similarity between the water down to a depth of 40 feet, and its abrupt change below this depth, indicates that the wind-storm before noted caused a thorough mixing down to this depth and that the water had not remained stagnant a sufficient length of time to regain its old conditions.

The presence of the larger amount of decomposable organic matter in the bottom layers, as compared with those near the surface, can readily be accounted for by the fact that all organic matter in the pond, whether derived from living organisms that had their growth in the waters, or brought in from outside sources, either by influent streams or blown in as leaves in autumn, tend to find their way to the bottom

layers, which thus become the field of decomposition of any matter from all the water of the pond. This points to the conclusion that, below the depth at which the water is kept well aerated by currents maintained by the action of the wind upon its surface, the amount of decomposition as revealed by the disappearance of oxygen depends upon the proximity to the bottom rather than to depth below the surface; and this fact is borne out by the results obtained from the simultaneous study of both shallow and deep ponds. One of the most marked characteristics of the water from the deeper layers is their greater color and the rapid increase of color on exposure to light and air.

The average of five different determinations made between the last of August and the first of November, when the water at the bottom is at maximum color, during three successive summers, shows that the water at the bottom on collection had a color equal to *six* times that of water at the surface, and that on exposure the color increased to *twenty* times that at the surface.

Under the direct action of sunlight, after the maximum color is reached, this coloring material is rapidly thrown out of solution, most of it settling out as a precipitate and the remainder can be removed by passing through filter paper. The rapidity of this action, which depends upon the active power of the sunlight, varies greatly with the season of the year.

A sample of water, collected October 6, 1891, from bottom of Chestnut Hill Reservoir, in which all oxygen had been exhausted, increased in color from .75 to 3.00 on exposure. After two weeks' exposure, only a small part of which was under the condition of sunlight, most of the color had disappeared, and upon filtering, it was found to be almost perfectly decolorized.

Practically this same result can be brought about in a much shorter time by a rapid oxidation by drawing air through such a sample with an aspirator. A sample from the bottom of Jamaica pond had a color, as soon as received at the laboratory, of .38, and was somewhat cloudy; on further exposure to the air for one hour its color was increased to .70. The color of another portion of the same sample was increased by aeration to 1.50, but on filtering through filter paper, its color was reduced to .38, its original color, showing that the material causing the color had been oxidized and existed in a state of suspension.

The turbidity of the water from bottom layers was always noticeable; and after its maximum color was reached, this turbidity rapidly became more marked, the particles finally

WATER ANALYSES. — BOSTON WATER-WORKS.

Sample kept in the dark. Parts in 100,000.

LOCALITY.	DATE OF		Color.	Total	RESIDUE ON EVAPORATION.		Chlorine.	NITROGEN.					Oxygen Consumed.	Hardness.	Total Nitrogen Equivalent.	REMARKS.
	Collection.	Examination.			Loss on Ignition.	Fixed.		ALBUMINOID AMMONIA.		Free Ammonia.	As Nitrites.	As Nitrates.				
								Unfiltered.	Filtered.							
Chestnut-Hill Reservoir, water from tap,	1891. July 17	1891. July 17	.30					.0162	.0154	.0000	.0001	.0200	.51	1.69	.0363	
" " "	" " "	August 18	.31	4.55	Filtered 1.25	Filtered 3.30		.0130	.0106	.0000	.0000	.0150	.51	1.56		Settled; only clear part tested.
" " "	" " "	September 18	.30					.0098	.0000	.0002	.0002	.0250	.39	1.63		" " "
" " "	" " "	October 16	.30					.0098		.0002	.0004	.0210	.56			" " "
" " "	" " "	1892. April 15	.25					Mixed .0192	.0072	Mixed .0004	.0000	.0250	Mixed .30 Filtered .38		.0356	

WATER ANALYSES. — BOSTON WATER-WORKS.

Sample exposed to sunlight. Parts in 100,000.

LOCALITY.	DATE OF		Color.	RESIDUE ON EVAPORATION.				NITROGEN.				Oxygen Consumed.	Hardness.	Total Nitrogen As usual.	REMARKS.	
	Collection.	Examination.		Total.	Loss on Ignition.	Fixed.	Chlorine.	ALUMINOID AMMONIA.		Free Ammonia.	As Nitric.					As Nitrate.
								Unfiltered.	Filtered.							
Chestnut-Hill Reservoir, water from tap,	1891. July 17	1891. July 17	.30					.0162	.0154	.0000	.0001	.0200	.51	1.69	.0363	Settled; only clear part tested.
" " "	" 17	August 18	.03	4.68	2.04	Filtered 2.64		.0128	.0128	.0004	.0001	.0120	.35	1.76		Exposed to 238 hours, bright sunlight. Settled; only clear part tested.
" " "	" 17	September 18	.00					.0136	.0134	.0008	.0003	.0150	.25	1.69		Settled; only clear part tested.
" " "	" 17	October 16	.00					.0144	.0000	.0000	.0000	.0000	.29			Exposed to 567 hours, bright sunlight.
" " "	" 17	1892. April 15	.00					Mixed .0142	.0110	Mixed .0176	.0022	.0030	Mixed .17 Filtered .16		.0370	

collected together and settled out as a flocculent brownish-red precipitate, having the appearance of precipitates of ferric iron. This, together with the presence of crenothrix, so generally associated with the presence of iron, in the bottom layers when the water showed the greatest tendency to darken, led me to determine the iron in the first sample from the bottom of Lake Cochituate. Manganese, which is similar to iron in the formation of its salts, was also found in the sample, and its determination was included in all subsequent analyses.

In the following table the relation between color and iron and manganese contents is shown for water from the bottom of Lake Cochituate and Jamaica pond.

The uniformly high results for iron and manganese, calculated from the color, using the factors deduced from averages, may be due to the difficulty in determining the initial color, as it darkens immediately on exposure.

In these examinations the amount of iron and manganese was determined in the residue from a considerable quantity of water by means of the basic acetate method.

Table showing the relation between Increase of Color on exposure to Light and Air during warm weather, and the Iron and Manganese contents of Water from the bottom of Deep Ponds.

LOCALITY.	No.	Date.	COLOR.			FE AND MN FOUND.				FE AND MN CALCULATED FR. COLOR.			
			On Collec-	After Ex-	Increase.	Fe.	Mn.	Total Fe. and Mn.		Fr. total Color.	Amt. dif. from that found.	Fr. inc. of Color.	Amt. dif. from that found.
Lake Cochituate	1	September 18, 1890,	1.20	3.70	2.50	1.13	.14	1.27		1.62.	+.35	1.55	+
"	2	October 31				1.80	.26	2.06					
"	3	July 17, 1891 . . .		1.30		.50	.07	.57		.57	.00		
"	4	August 19	1.00	3.20	2.20	.97	.20	1.17		1.40	+.28	1.36	+
"	5	September 28 . . .		3.40	2.20	.96	.21	1.17		1.49	+.32	1.36	.19
"	6	October 23	1.20	4.00		1.32	.29	1.61		1.76	.15		
"	7	October 27, 1892 . .	.75	3.00	2.25	.80	.24	1.04		1.26	+.28	1.39	+.25
Jamaica Pond	8	September 11, 1890,	.38	1.50	1.12	.50	.09	.59		.66	+.07	.69	.10
"	9	October 25, 1892 . .	.15	1.30	1.15	.41				.57		.71	
Averages	. . .		.78	2.68	1.90	.93	.19	1.18			.2		.20

.1 color calculated from total after exposure = .44 $\left\{ \begin{array}{l} \text{Fe.} \\ \text{Mn.} \end{array} \right.$
 Increase of .1 color above average on collection, .78 = .62 $\left\{ \begin{array}{l} \text{Fe.} \\ \text{Mn.} \end{array} \right.$

The presence of this large amount of iron in the bottom of ponds may be explained in the same way as the production of pond and bog iron ore.¹ All surface waters coming from a district covered with vegetation contain more or less iron. This iron is derived from two sources: the vegetation itself, which will be discussed under Iron in Surface Waters, and from the soil and iron-containing rocks.

As before stated, the ultimate end of the carbon of organic matter is carbonic acid. If there is a lack of oxygen from atmospheric sources to support this decomposition, the organic matter takes it from any available ferric oxide, thus converting the iron to a soluble ferrous salt, in which form it is carried off with the surface water.

During its passage, or at least upon reaching a pond where the surface portion into which it enters is well aerated by being kept in a state of motion by the wind, the iron is reoxidized to a precipitate of ferric hydrate. This falls of its own weight to the bottom, where it gives up its oxygen for the further oxidation of the organic matter which is there undergoing decomposition.

The iron is thus nearly all reduced to the ferrous or colorless form, which by its oxidation on exposure after collection causes the increase of color due to its presence in the ferric condition. In the presence of the organic matter this ferric iron remains soluble for a time, but finally settles out as ferric hydrate, leaving the water colorless.

Thus it will be seen that the iron, so far as it is received into a pond, aids by giving up its oxygen in the oxidation or purification of the water at the bottom of the pond.

The determination of the oxygen consumed, which is a measure of the oxidizable carbonaceous matter existing in the water in a state of solution, represents the decomposed portion of the organic matter which causes the reduction of the iron and with which much at least of the iron is probably in combination. The presence of this material in the case of surface waters is of even more importance in influencing the color, and it will be further discussed under that head.

Iron, when thus deposited in ponds which contain an insufficient amount of organic matter to reduce it all to the soluble condition, forms pond ore which is similar to bog ore deposited in swamps. These deposits of pond ore seem to be of very general occurrence. Hansman describes their occurrence in Scandinavian lakes where their formation is

¹ Formation of Bog and Pond Ores. N. H. and H. V. Winchell's Report on Iron Ores of Minnesota, p. 221.

very rapid. Honeyman¹ describes their occurrence in Grand Lake, Nova Scotia, and Swank² records their presence in many of the ponds of Eastern New England, from which in early times it was collected as a source of iron.

My analysis of such an ore, collected in October, 1892, from the bottom of Sandy pond in Lincoln is of interest, as it shows that this sample contained much more manganese than iron :

Loss on ignition	21.51
Insoluble residue	20.49
Fe ₂ O ₃	24.40
Al ₂ O ₃	3.00
Mn O ₂	37.34
	97.74

An analysis of ooze collected from the bottom of Lake Cochituate late in September, 1890, at a time when there was no oxygen in the bottom layers, and when most of the iron must have been in solution, shows the presence of 2.04% of Fe = 2.91% Fe₂ O₃.

Tank 2.

Tank 2 at Chestnut Hill, which is a six-foot tank of cypress, had at the time the experiment was made, a thin layer of stones in the bottom. It was washed and filled with reservoir water on July 25, 1890, and on July 28 a dissolved oxygen sample taken at the outlet showed that the water in the bottom of the tank was entirely deoxidized.

July 31, 1890, temperature, surface 80°.

“ underdrain 77°.

“ outlet 69.5°.

After cleaning the outlet pipe the effluent was entirely deoxidized; after running 10 gallons, effluent, 3% saturated; after running 60 gallons, effluent, 11% saturated; after running 500 gallons, effluent, 33% saturated.

The effluent first drawn from the tank had a strong pungent odor, and after drawing 1,500 gallons a faint trace of the odor remained. The samples collected darkened on standing, and a red flocculent precipitate settled out, which in nearly every case contained crenothrix.

On August 8, 1890, the effluent, after clearing the pipe,

¹ Pamphlet — Nova Scotia Superficial Geology — Transactions of the Royal Society, Canada. Vol. 1.

² Statistics of Iron and Steel Production of the United States, Census 1880.

had a strong pungent odor and was entirely deoxidized, and after drawing 500 gallons the same odor could be detected, and the water was only 57% saturated.

The color of the first two samples taken was darker than the others, and increased on standing.

The tank was refilled after taking the series August 8, and on August 13 the disagreeable odor again appeared at the outlet, and a sample showed no dissolved oxygen.

On August 22 the effluent had a very disagreeable and pungent odor, some of the first drawn gave a faint test for hydrogen sulphide.

On August 29 six large bottles of effluent were collected through a tube into the bottom of the bottles to prevent oxidation, to be kept for experiment.

The six samples taken August 29, 1890, remained unopened, but exposed to the light for about a month, after which they were set away in a dark cupboard.

When collected they had a color of from .4 to .5, and darkened somewhat on standing. On March 24, 1891, they were opened and examined with the following result:

No. 1, color .18, contained slight white precipitate, abundant test for H_2S .

No. 2, color .06, heavy red precipitate, Fe and organic matter, no odor nor H_2S .

No. 3, color .07, heavy red precipitate, no odor nor H_2S .

No. 4, color .09, some red precipitate, no odor nor H_2S .

No. 5, color .09, some red precipitate, no odor nor H_2S .

No. 6, color .10, slight red precipitate, no odor nor H_2S .

No. 1 aerated for twenty minutes read .80, and the odor of hydrogen sulphide disappeared, a red precipitate of iron slowly accumulated, showing that the sample held as much iron as the others, but that it had been reduced to the ferrous or colorless form.

The same disappearance of oxygen and the development of a deeper color in the lower layers were noticed in Tank 1, which was of cypress, similar to Tank 2.

The color of the water in the tanks, as viewed from the surface, appeared to become lighter on exposure in the tank.

These experiments show that the action that goes on in a six-foot tank and in a gallon bottle, when tightly stoppered, is the same as that at the bottom of a deep pond.

The reduction of the iron in only the first sample drawn from Tank 2, may be explained by the fact that this contained more putrescible organic matter than the others, as it represents the water at the extreme bottom of the tank, which

contained the organic matter collected from all the water stored in it.

REDUCTION EXPERIMENTS.

The reduction of the precipitate of ferric iron, in the case of the water contained in the bottle, which must have been accomplished by the growth of micro organisms led me to make the following experiments to see how rapidly and to what extent ferric iron could be reduced under known conditions. In all the following experiments the liquid entirely filled the bottle, so that the liquid when once deoxidized might not by contact with the air take on more oxygen and retard the reduction. Sugar was added to the amount of 1 gram per 100 cubic centimetres, and it was seeded with fresh yeast and the temperature maintained at 80° F.

Tests made on all before allowing them to stand showed that none contained ferrous iron.

WATER FROM CEDAR SWAMP.

A dark swamp water, color 4.0, had been standing in the laboratory for some time; all the iron was oxidized, part of which had settled out with organic matter as a brown precipitate. After standing four days a faint test for ferrous iron was obtained, and the amount of ferrous iron was shown by frequent tests to increase regularly. After standing two weeks the dark-colored precipitate had disappeared, as well as the brown color of the water, although so turbid as to make an accurate test of its color impossible.

FERRIC CHLORIDE.

This test was made in the same way, using distilled water, to which sufficient ferric chloride was added to give a color of about 1.0. Under the same conditions, the first test for ferrous iron was obtained after six days of growth, and this increased until the experiment was discontinued after about four weeks.

FERRIC HYDRATE.

This test was made under the same conditions as the others, using .3125 grams of ferric hydrate ($\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), obtained by precipitating the iron in this form from .1682 grams of iron. After four days of action the mixture gave an abundant test for ferrous iron, and the amount increased regularly.

After seven weeks of action the mixture was filtered rap-

idly through a large ribbed filter, and the amount of ferrous iron in solution derived from the ferric hydrate added was determined. It was found to amount to 12.03%.

The liquid containing the ferrous iron was turbid and greenish yellow.

On exposure and during evaporation it became a dark brownish color, and when nearly evaporated the iron settled out as a reddish brown flocculent precipitate. It had every appearance of a dark natural water exposed under the same conditions.

IRON IN GROUND WATER.

It is a well known fact that ground water often contains sufficient iron in solution to cause by its oxidation on exposure a decided color. This has been studied by Peifke¹ and Fränkel with reference to city supplies derived from ground water in certain parts of Germany.

They devised a method for its purification, depending upon the rapid oxidation of the iron, by passing it in the form of spray through a column of coke, and the subsequent removal of the precipitated iron by filtering rapidly through a shallow sand filter. As most of my work has been confined to the source of supply of the Boston water, which is derived entirely from surface water, comparatively few such waters have come to my attention.

Many of our springs,² which represent the ground water, are known to be chalybeate.

My determination of the amount of dissolved oxygen in water flowing from artesian wells situated in different portions of the Boston basin, and which were taken late in November when nearly the maximum amount of dissolved oxygen is present, show by the very small amount of dissolved oxygen present that the conditions, during part of the year at least, are favorable for the reduction and solution of iron by the water, which, upon exposure, would cause a color due to its oxidation.

DISSOLVED OXYGEN IN FLOWING ARTESIAN WELL-WATER.

17 feet below normal grade of surface, 12.92% saturation.

22.85 feet below normal grade of surface, 3.48% saturation.

34.38 feet below normal grade of surface, .89

41.60 feet below normal grade of surface, 2.26 saturation.

¹ Filteranlagen für Städtische Wasserleitung.

² Peale. — Mineral Springs of the U. S., p. 21.

The average per cent. of saturation of three flowing wells having depths of about forty feet, but situated comparatively near the outcrop of the ledges forming the base of the drainage area was, on December 1, 1892, 25.5.

An analysis made the last of November of gas bubbling from the bed of a shallow spring showed that it contained less than half the amount of oxygen found in air.

Such water, especially if it contains also organic matter in solution, is especially favorable for the growth of crenothrix and allied forms. Frequently such ground-waters upon coming to the surface as springs, support these growths to such an extent as to cause a considerable accumulation of ferric oxide. An analysis of a deposit formed in this way shows the following composition :

Loss on ignition	.	.	.	.	.	33.3%
Insoluble residue	.	.	.	.	.	8.3%
Fe ₂ O ₃	.	.	.	.	.	58.3%
MnO ₂	.	.	.	.	.	.1%

CAUSE OF THE COLOR OF SURFACE-WATER.

The color of a surface-water, as one from a brook or river which is kept well aerated by coming in contact with the air, forms, in some ways, a decided contrast with the dark waters from the bottom of ponds. One of the most marked points of difference is, when protected from the light, the greater permanence of its color, so great, in fact, is the permanence after the putrescible organic matter in suspension is removed by filtration (preferably by filtration through a sheet of sandstone or porous tile) that it may be kept practically indefinitely without loss of color, provided it is carefully protected from the light. A sample of a dark surface-water when thus filtered, may, by dilution with distilled water, be made to match in intensity of color the Nesslerized ammonia standards which are used for reading the color of water, and a set of color standards thus made has the advantage of being of the exact hue of the waters examined. Such a set has been used in reading the color of waters examined for the city of Boston, and also for the Massachusetts State Board of Health, since June, 1890, and some of the first color standards are still in use.

As stated at the beginning of the paper, the color depends to a certain extent upon the nature of the materials from which it is derived. A sample collected in May or June is generally a clear brownish yellow, and represents a mean between the extremes of the greenish-yellow color imparted

by freshly decomposing organic matter and the dark brown of older material.

In order that the color may remain permanent it is necessary, as stated above, to protect the water carefully from the light.

On the following sheet are given analyses of samples of water collected from the tap at the Filter Station, which represents a sample from the well aerated portion of the Chestnut-Hill Reservoir, one kept in the dark, which retained its color, the other exposed to sunlight and which was decolorized after a month.

If there is a similarity between the cause of the color of a surface-water and that from the bottom of a pond, the color of which has been shown to depend upon the presence of iron and manganese, it is clear that there should be found in the surface waters varying amounts of iron and manganese according to the color present.

As a natural water is an infusion of organic matter, a set of preliminary experiments was made to determine the amount of iron in different leaves, and in peat and peat-forming material, which upon their decomposition would be added to the water.

AMOUNT OF IRON IN DIFFERENT LEAVES.

Maple leaves contain 42.0 parts per 100,000 = .042% ; 1 ton contains 1.20 lbs. Fe_2O_3 .

Elm leaves contain 52.0 parts per 100,000 = .052% ; 1 ton contains 1.48 lbs. Fe_2O_3 .

Chrysanthemum leaves contain 53.4 parts per 100,000 = 0.53% ; 1 ton contains 1.56 lbs. Fe_2O_3 .

The amount of iron in different colored leaves of the same species (coleus).

Amount taken, 1 gram of fresh leaves :

Color.	Parts per 100,000.		
	Iron extracted in 36 hours in 30% alcohol.	Iron remaining in leaf.	Total iron in leaf.
Purplish black . . .	3.0	4.0	7.0
Purple and pink . . .	2.0	5.0	7.0
Yellowish green . . .	1.0	3.5	4.5
White	.5	3.8	4.3

The chlorophyl of leaves was formerly considered to be the part which contained the most iron, but more recent work has shown that the iron is practically confined to

the cells and is not part of the chlorophyl. An examination was made of chlorophyl extracted with chloroform from chrysanthemum leaves, using Soxhlets' apparatus. This extractive matter, consisting mainly of chlorophyl, was found to contain only 1.4 parts per 100,000. of its weight of iron, which represented only 3.3% of the iron contained in the leaf.

That the iron in whichever part it exists is extracted by means of water, is shown by the following experiments:

By boiling 20 minutes, 69.2% of the iron is removed from maple leaves, and 47.7% from elm leaves.

THE COLOR AND AMOUNT OF IRON AND MANGANESE IMPARTED TO ONE LITER OF DISTILLED WATER BY ONE GRAM OF LEAVES.

MAPLE LEAVES.

	Parts per 100,000 of solution.			Total Fe and Mn.
Extracted 8 days.	Color .37	Fe = .0034.	Mn = .0020	.0054
Subsequent extraction, same leaves,	" .20.	Fe = .0006.	Mn = —	.0006
Boiled 15-20 minutes	" 24.00.	Fe = .2560.	Mn = .1700	.4260
	.1 color = .018 parts Fe and Mn.			

ELM LEAVES.

	Parts per 100,000 of solution.			Total Fe and Mn.
Extracted 8 days.	Color .22.	Fe = .0016	Mn = .0040	.0056
Subsequent extraction, same leaves,	" .20.	Fe = .0011	Mn = —	.0011
Boiled 15-20 minutes,	" 15.00.	Fe = .2400	Mn = .2000	.4400
	.1 color = .016 parts Fe and Mn.			

THE DETERMINATION OF THE AMOUNT OF IRON IN DIFFERENT PEAT-FORMING MATERIALS, AND IN PEAT AT DIFFERENT DEPTHS.

(Samples from Cold Spring Swamp, Newton.)

All of the determinations of iron in leaves and their decoctions have been confined to the commoner species of trees, as the maple, elm, and oak. The leaves of such trees, although abundant in swamps, where they are blown by the wind in autumn and find a lodgement, do not, however, add very materially to the accumulation of peaty material, which is the natural coloring matter of surface-waters.

Peat is an accumulation of organic matter generally under water, where the decomposition, or the destruction of the material is less rapid than its accumulation.

The under part of such a deposit gradually becomes changed to the fine black mud or muck which is mixed with

some sand. A sample of this black mud taken at a depth of from two to three feet contained but 13.4% of ash, the remaining 86.6% being volatile and organic matter. Tree stumps exposed on the surface of a deposit of peat pass through the state of brown vegetable mould, and are finally incorporated with the deposit; those embedded while sound in the mass of peat, remain almost indefinitely without decomposition.

AMOUNT OF IRON IN 1 GRAM OF DIFFERENT MATERIALS.
(DRIED AT 100° C.)

Leaflets of Common brake	.000065g = .006%
Meadow grass, growing from tussock	.000065g = .006%
Meadow moss, fresh	.000380g = .038%
Meadow moss, one year or more old, and some grass	.001900g = .190%
Recent peat, from tussock	.000340g = .034%
Brown vegetable mould, from decayed stump	.002100g = .210%
Black peaty muck, from 2 to 3 feet	.009200g = .920%

The Color and Amount of Iron in Surface-Waters.

	Color.	O cons'd.	PARTS PER 100,000.				Amount of Fe differing from that found.
			Fe.	Mn.	Total Fe and Mn.	Amount of Fe calc'd for color.	
Boston tap	.45	. . .	.014	. . .	. . .	.030	+ .016
Lake Cochituate, surface	.22	.41	. . .	. . .	. . .	.014	
“ “ “	.64	.59	.060	.040	.100	.043	— .017
“ “ “	.24	.48	.030	.050	.080	.016	— .014
“ “ “	.20	.43	.060	.030	.090	.013	— .047
“ “ “	.15	.44	.110	.040	.150	.010	— .100
“ “ “	.15	.34	.110	.040	.150	.010	— .100
Basin 3, surface	.62	.62	.070	.030	.100	.041	— .029
“ “ “	.68	.69	.040	.030	.070	.045	+ .005
“ “ “	.60	.72	.100	.040	.140	.040	— .060
“ “ “	.35	.65	.170	.030	.200	.023	— .147
“ “ “	.31	.34	.040	.020	.060	.020	— .020
“ “ “	.50	. . .	. . .	. . .	. . .	.033	
Basin 4, surface	.69	.70	.070	.100	.170	.045	— .024
“ “ “	.58	.64	.050	.020	.070	.038	— .012
“ “ “	.50	.67	.060	.020	.080	.033	— .027
“ “ “	.42	.73	.060	.030	.090	.028	— .032
“ “ “	.25	.58	.110	.040	.150	.016	— .094
Dismal Swamp, Va.	6.25	. . .	.312	. . .	. . .	.418	+ .106
Cedar Swamp	4.00	. . .	.255	. . .	. . .	.268	+ .013
Westboro' series, September 22, No. 1	.43	.46	.017	. . .	. . .	.028	+ .011
“ “ “ “ “ 2	.07	.21	.014	. . .	. . .	.004	— .010
“ “ “ “ “ 3	.08	.25	.021	. . .	. . .	.005	— .016
“ “ “ “ “ 5	.24	.38	.014	. . .	. . .	.016	+ .002
“ “ “ “ “ 6	.06	.17	.009	. . .	. . .	.004	— .005
“ “ “ “ “ 7	.10	.24	.017	. . .	. . .	.006	— .011
“ “ “ “ “ 8	.85	.80	.019	. . .	. . .	.057	+ .038
“ “ “ “ “ 9	2.30	1.96	.037	. . .	. . .	.154	+ .117
“ “ “ “ “ 10	1.75	1.54	.035	. . .	. . .	.117	+ .082
“ “ “ “ “ 1	.48	.46	.005	. . .	. . .	.032	+ .027
“ “ “ “ “ 2	.05	.29	.009	. . .	. . .	.003	— .006
“ “ “ “ “ 3	.12	.25	.019	. . .	. . .	.008	— .011
“ “ “ “ “ 4	.55	.55	.007	. . .	. . .	.036	+ .029
“ “ “ “ “ 5	.14	.26	.006	. . .	. . .	.009	+ .003
“ “ “ “ “ 6	.41	.42	.007	. . .	. . .	.027	+ .020

Color and Amount of Iron in Surface-Waters. — *Continued.*

	Color.	O cons'd.	PARTS PER 100,000.				Amount of Fe differing from that found.
			Fe.	Mn.	Total Fe Mn.	Amount of Fe calc'd for color.	
Westboro' series, September 22, No. 7 . .	.12	.21	.020	...	...	.008	— .012
“ “ “ “ “ 8 . .	.95	.78	.015	...	...	.063	+ .048
“ “ “ “ “ 9 . .	1.60	1.62	.022	...	...	.107	+ .085
“ “ “ “ “ 10 . .	1.70	1.55	.035	...	...	.113	+ .078
Indian Brook	2.80	2.68	.042	...	...	.187	+ .145
Whitehall Pond, shallow flowage	.70	.83	.010	...	...	.046	+ .036
“ Upper Pond	.48	.52	.016	...	...	.032	+ .016
“ Pond at weir	.76	.83	.010	...	...	.050	+ .040
Chestnut-hill Reservoir	.40	.46	.017	...	...	.026	+ .009
“ “	.51	.49	.022	...	...	.034	+ .012
“ “	.52	...	.019	...	...	.008	— .011
“ “	.51	.49	.014	...	...	.034	+ .020
“ “	.63	...	.022	...	...	.042	+ .020
Tank 6, effluent	.11	.32	.012	...	...	.007	— .005
“ 13 “	.00	.08	.010	...	...	.000	— .010
“ 6 “	.17	.34	.008	...	...	.011	+ .003
“ 13 “	.02	.09	.009	...	...	.001	— .008
“ 14 “	.10	.30	.017	...	...	.006	— .011
“ 16 “	.00	.03	.011	...	...	.000	— .011
“ 6 “	.20	...	.008	...	...	.013	+ .005
“ 13 “	.01	...	.002	...	...	.000	— .002
“ 18 “	.00	...	.006	...	...	.000	— .006
“ 13 “	.02	.07	.009	...	...	.001	— .008
Influent stream, Quincy Reservoir . . .	.70	.39	.065	...	...	.046	— .019
Quincy Reservoir	1.25	.58	.205	...	...	.083	— .122
Randolph Brook	.65	.51	.015	...	...	.043	+ .028
Houghton Pond	.04	.16	.008	...	...	.002	— .006
Oak Ridge, N. J. Reservoir	.15	.48	.020	...	...	.010	— .010
Average	.64	...	.043	...	...	...	...

.1 color corresponds to .0067 parts Fe per 100,000.

THE ACTION OF REAGENTS ON COLORED SURFACE-WATER.

Hydrogen peroxide acts as a decolorizing agent of a dark surface-water. The addition of 10% of a 20-volume solution discharged 70% of the color of a surface-water reading 4.0, in 10 hours, and completed the decolorization within two weeks. A very slight precipitate was formed.

As commercial hydrogen peroxide contains a little hydrochloric acid, a blank determination was made, using the amount of hydrochloric acid present in the hydrogen peroxide used. Although somewhat more rapid than when caused by the action of diffused light it was shown that the decolorization was not increased by the presence of this very small amount of hydrochloric acid.

Nitric, sulphuric, and hydrochloric acids, when present in considerable quantities, aid the decolorization, the rapidity depending on the amount present. They prevent the formation of a precipitate.

Caustic potash increases the color; in many cases doubling it. No precipitate forms, even upon long continued boiling with a concentrated solution.

Flocculent alumina, which completely decolorizes the water, removes, at the same time, the iron.

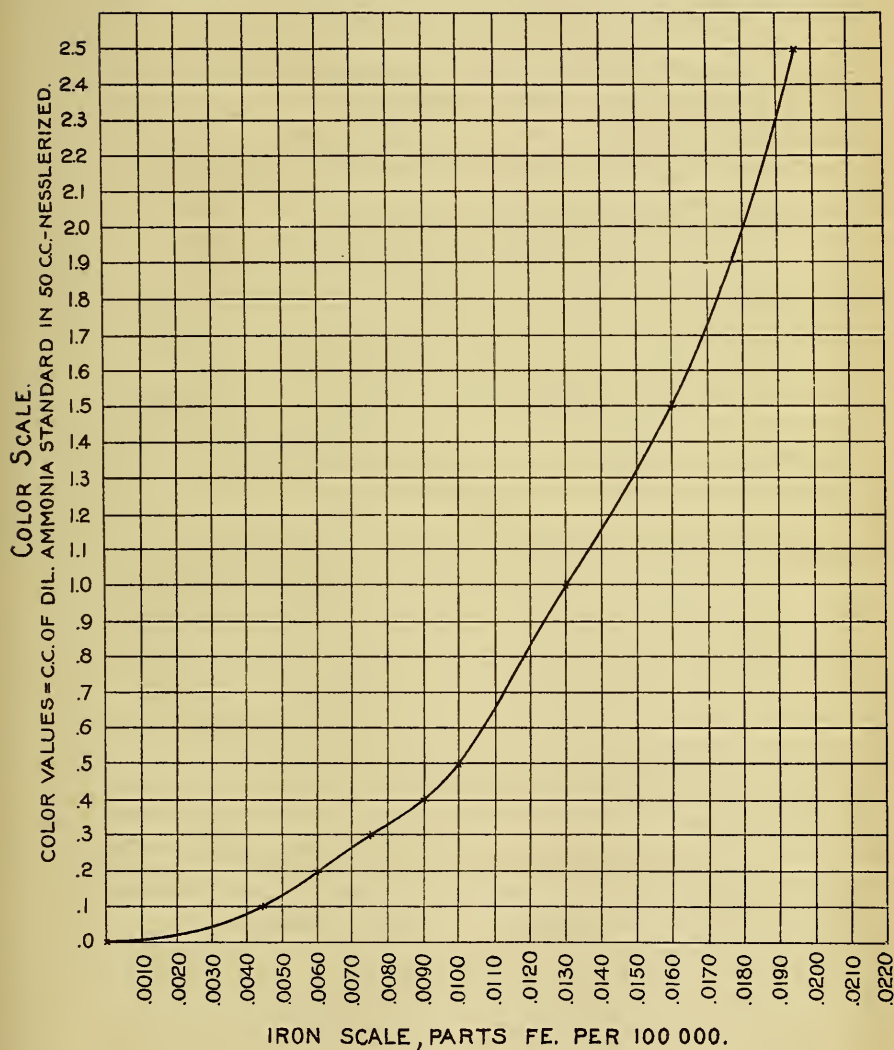
The presence of certain organic substances prevents the precipitation of iron as ferric hydrate, and when the iron is thus held in solution it imparts a color to the liquid. By thus imparting color to distilled water, sufficient to match the color of samples of surface-water of known iron contents, it should, clearly, be possible to determine what part of the color of the surface-water is caused by the iron.

An experiment of this kind was made, using some of the commoner organic substances that prevent the precipitation of ferric salts. Ferric iron in the presence of glycerine causes a reddish color; of tartaric acid, a greenish-yellow color; of sugar, a clear yellow color; and of tannin, with which it gives a black color in the case of strong solutions, in very dilute solutions gives a purplish red.

It is clear that these last two are the ones most likely to be present in surface-water, the sugar from sap and tannin extracted from the bark. The presence of these two would also account for the brown hue of a natural water.

Such an artificial colored water, colored by iron held in solution by means of sugar, with a few drops of dilute tannin solution to give the required hue, matched perfectly a natural surface-water; but it was necessary to add nearly ten times as much iron as was calculated from the average of such waters — .1 color = .0067 parts of Fe per 100,000.

PLOT SHOWING THE AMOUNT OF IRON IN NATURAL WATER STANDARDS.
 WATER USED IN MAKING STANDARDS FROM CEDAR SWAMP - WESTBORO, MASS.



From this, together with the fact that the amount of iron corresponding to a color of .1 is, in the case of a surface-water, only one sixty-fifth of that in a colored water from the bottom of a deep pond, it is necessary to conclude that the color of a surface-water is practically independent of the iron contents.

The cause of the color of a surface-water is, therefore, mainly the organic matter in solution, and it will be noticed on the foregoing table that the organic matter, as revealed by the test of oxygen consumed, follows closely the color.

REPORT OF THE SUPERINTENDENT OF THE MYSTIC DIVISION.

SUPERINTENDENT'S OFFICE,
CHARLESTOWN DISTRICT, February 1, 1893.

ROBERT GRANT, Esq., *Chairman Boston Water Board* :

SIR: The report of the Mystic Division of the Boston Water-Works from February 1, 1892, to February 1, 1893, is herewith submitted.

MYSTIC LAKE.

Water overflowed the dam almost constantly until June 7, and again from June 27 to July 7. From this date the surface of the lake gradually lowered until November 1, when the lowest depth during the year was recorded, 6.72 feet below high water, or 1.28 feet above the point at which it would be necessary to pump the water into the conduit. This was 4.45 feet above the conduit invert. On December 1 it was 2.63 below high water, and on January 1 it was 1.50 below. In October, the temporary engines and feed-pump were overhauled, new grate-bars put in the boilers, the centrifugal pumps, after being patched in several places, were lowered into place, and all arrangements completed for the expected pumping. Fortunately, after November 1, the water rose, and quite rapidly, so the preparations were abandoned. The lake, ponds, rivers, and feeders received all the required care and attention. Wedge and Horn ponds and that section of the Abajonna river above Whitney's dam were constantly patrolled during the warm season, and all objectionable algæ and other contaminating matter removed. All along the banks of the supply, overhanging shrubs were cut away, and where needed the beds of the streams were raked and gravelled. The gate-keeper's house and the engine-house received some slight repairs and the roads and fences near the dam were trimmed and improved.

RESERVOIR.

The stonework in the basins of the reservoir has been repointed with Portland cement, the brickwork repaired in several places, and both basins have been thoroughly cleaned. When preparing to make these improvements,

the drain, a sheet-iron cement-lined pipe, was found to be defective, so 36 feet of new 12-inch cast-iron pipe was substituted. The banks have been top dressed, as usual, and about 100 feet of one of the adjoining roads graded and repaired. The gate-house, walks, seats, banks, roads, and fences are now in good condition. I respectfully recommend that next spring the bottoms of both basins be reconcreted.

CONDUIT.

During the past year the conduit has been twice cleaned, flushed, and inspected, and at the last inspection it was found in good order.

I intend the coming season to place a 36-inch gate and pipe on the blow-off, in order to expedite the cleaning and flushing, and to better exclude the tide-water. I shall also place new sills and grooves for the screens in the screen-chamber, and shall raise the roof of the chamber to facilitate the changing of the screens. The force mains are in good condition.

PUMPING-STATION.

During the year the consumption on this division increased 11.8 per cent. over that of last year. In January, 1893, owing to the extreme cold weather, the consumption was greater than that of any previous month. A daily average of over 14,000,000 gallons was pumped, and on several days the pumping exceeded 16,000,000 gallons.

The estimated pumping capacity of the three pumps is but 18,000,000 gallons daily, so it was necessary to run the pumps to almost their full extent. If the 8,000,000-gallon pump had broken down, the two 5,000,000-gallon pumps could not have supplied the demand. One of the 5,000,000-gallon pumps has been in use since 1864, the other since 1866, and the 8,000,000-gallon pump since 1872.

These pumps require repairs frequently, and especially Pump No. 1, a 5,000,000-gallon pump. I respectfully call the attention of the Board to the above facts, and to the expediency of replacing Pump No. 1 with a new one of at least 12,000,000 gallons pumping capacity. In December, a Lamprey Patent Furnace-mouth Lining was placed in each of the six boilers on a six months' trial.

A new feed-pump has been set up in the boiler-room, the dynamo repaired, new fronts similar to those on boilers Nos. 4, 5, and 6 have been put on boilers Nos. 1, 2, and 3, six new windows put on east end of engine-house, 800 feet of coal-car tracks relaid, and painting and papering done at the engineers' residences.

I respectfully recommend, as a matter of economy, that a larger chimney be erected, as the present one is of insufficient draught.

MYSTIC-VALLEY SEWER.

From February 1, 1892, to February 1, 1893, 135,459,762 gallons of sewage was pumped, to which was applied as a precipitant, 340,608 lbs. of crude sulphate of alumina. The quantity of sludge precipitated and subsequently pumped during the same time was 3,326,806 gallons. The greater part of this sludge, when sufficiently hard to handle by excavation, was carted away by farmers, who used it as a fertilizer. The quantity of coal used was 358,685 lbs., or 179.34 tons. The quantity of sewage pumped during the year ending January 31, 1893, exceeded that of the corresponding months of the preceding year by 11 per cent., as likewise the amount of precipitant used, while in the amount of coal used there was a decrease of nearly 7 per cent.

The buildings at this station are in good condition, but the tanks are beginning to show signs of weakness. In August, the floor of Tank No. 4 was raised several inches by the pressure of water due to the leakage of the adjoining Tank No. 3; at the same time, the partition separating the tanks was thrown out of position, thereby rendering both tanks unfit for use until repaired, which required about four weeks' time. The sludge-gates in the tank building, and the flumes that convey the sewage to the several tanks were repaired, new tubes put in the boiler and two patches made; the feed-pump was repaired, and the suction-pipe from the lake uncovered, in order to remove the defective lengths, and to make new joints. The coal-bin was strengthened, and one of the chemical vats repaired.

The sulphate of alumina was formerly shipped to us in barrels, but is now delivered in bulk. In order to expedite the unloading from the railroad cars, the chemical building was moved nearer the track. Now the alumina can be shovelled from the cars into the building, similar to the arrangements for the coal.

SEWAGE TREATMENT AT STONEHAM.

At Tidd's tannery in Stoneham arrangements have been made for chemically treating the sewage from these premises, and subsequently filtering it. The plant consists of two tanks, built of wood, each twenty feet in width by thirty feet in length, situated side by side, and having a working capacity of 22,500 gallons per day.

The floors of the tanks slope toward each other, and deliver into open drains, which are divided by the partition that separates the tanks. These open drains slope toward and discharge into a brick well, from which the sludge is pumped into settling basins on the adjacent grounds. The effluent water is to be discharged through numerous holes, bored through one end of the tanks on to an apron floor, which discharges into an 8-inch pipe, laid under the railroad and connected with the filters.

Two filters have been built on the meadow opposite the tannery, adjoining the railroad location. They are each 60 feet square, with embankments built of turf and soil, and are provided with sluice-gates to regulate the flow of the water.

The drainage material of the filters is nine inches in depth, and was laid on a plank flooring. This filtering material consists of ordinary sand, about as coarse as fine mortar sand, and has an average depth of two feet three inches. It is designed to use the filter intermittently, at the rate of 350,000 gallons per acre, per day.

The power required for pumping the sewage and sludge is to be furnished by the tannery company, at their expense, as soon as their new engine is ready for action.

POLLUTION INSPECTION.

Work in this department has been conducted in a diligent and systematic manner. The total number of cases inspected during the year is 681, of which 605 are old cases and 76 are new cases. The inspected cases are in the following condition: 383 "Present Safe," 83 "Seem Safe," 62 "Remedied," 68 "Suspected," 85 "Unsatisfactory."

FILTRATION EXPERIMENTS.

The experiments in filtering water at the filtering station in West Medford have been continued with satisfactory results.

The reports of analyses made by Professor Drown, of the Massachusetts Institute of Technology, encourage the continuation of the experiments.

DISTRIBUTION-PIPES.

The distribution-pipes have been extended by the addition of 36 feet of 3-inch pipe, 2,101 feet of 4-inch pipe, 15,741 feet of 6-inch pipe, 2,884 feet of 8-inch pipe, 187 feet of 10-inch pipe, and 120 feet of 16-inch pipe.

There are remaining in Charlestown 6,350 feet of cement-lined pipe, varying in size from 2 inches to 20 inches.

HYDRANTS AND GATES.

One hundred and seven new Post hydrants have been established and twenty-one old ones removed.

One hundred and ten new gates have been set, two 20-inch, two 12-inch, four 10-inch, seven 8-inch, seventy-three 6-inch, twenty-one 4-inch, and one 3-inch.

SERVICE PIPES AND BOXES.

One thousand and thirty new services were laid, distributed as follows: Charlestown, 47; Chelsea, 151; Everett, 303; and Somerville 529, in which 32,039 feet of lead pipe were consumed.

One hundred and fifty services were repaired. Twenty-eight $\frac{1}{2}$ -inch tin-lined services were removed and $\frac{5}{8}$ -inch substituted. Fourteen wooden service-boxes have been replaced by iron ones.

Fifty-five stoppages by eels, seventeen by rust, and six by moss were forced out. Nineteen leaking services were repaired and eight frozen ones thawed out.

New Services.

Size.	$\frac{5}{8}$ -in.	$\frac{3}{4}$ in.	1-in.	5-in.	6-in.	Total number.	Total ft.
Number	26	15	3	1	2	47	1,395

Summary of Services connected with Works, February 1, 1893.

	Charlestown.	Chelsea.	Everett.	Somerville.	Total.
Number of services	6,034	5,382	2,690	7,482	21,588
Number of feet	161,464	144,513	54,078	252,904	612,959

Breaks and Leaks on Distribution-Pipes.

Size of Pipes	2-in.	3-in.	4-in.	6-in.	8-in.	16-in.	
Charlestown	1	...	...	1	1	1	4
Chelsea	2	...	20	10	2	...	34
Everett	...	2	18	26	2	...	48
Somerville	...	3	31	47	47	...	128

Distribution-Pipes Relaid.

LOCATION.	Original Size.	4-in.	6-in.	8-in.	10-in.	12-in.	14-in.	16-in.	20 in.	Total.
Charlestown, Linwood pl.	4-in.	...	216	...	...	...	...	...	...	216
Chelsea	4-in.	...	3,598	...	...	...	...	...	...	3,598
Chelsea	6-in.	...	927	...	...	...	...	...	...	927
Everett, Nicholas st. . .	8-in.	...	...	...	40	...	...	...	...	40
“ Ferry st.	6-in.	...	32	346	700	...	...	...	...	1,078
“ High st.	6-in.	...	...	400	...	...	...	...	...	400
“ Tufts court . . .	4-in.	391	...	...	...	...	...	...	...	391
“ School st.	4-in.	...	...	...	2,150	...	...	...	...	2,150
“ Main st.	6-in.	...	...	...	1,310	...	...	...	...	1,310
“ Oak st.	4-in.	...	12	...	...	...	...	...	...	12
“ Corey st.	4-in.	...	59	...	...	...	...	...	...	59
“ Chelsea st.	6-in.	...	...	34	...	1,157	...	50	...	1,241
“ Union ave.	3-in.	...	16	...	...	...	...	...	...	16
“ Paris st.	4-in.	...	830	...	...	...	...	...	...	830
“ Winthrop st. . . .	4-in.	...	50	...	...	...	...	...	...	50
“ Liberty st.	4-in.	...	17	...	...	...	...	...	...	17
“ Linden ave.	4-in.	...	17	...	...	...	...	...	...	17
“ Baldwin ave. . . .	4-in.	...	21	272	...	...	...	...	...	293
“ Tremont ave. . . .	6-in.	...	...	700	...	...	...	...	...	700
“ Elmwood pl.	4-in.	244	...	...	...	...	...	...	...	244
“ Broadway	10-in.	...	...	...	...	...	...	...	2,900	2,900
Somerville	4-in.	36	...	...	...	...	...	...	...	36
Somerville	6-in.	...	5,786	...	...	...	...	...	...	5,786
Somerville	8-in.	...	...	4,094	...	...	...	...	...	4,094
Somerville	10-in.	...	...	...	4,361	...	...	...	...	4,361
Somerville	12-in.	...	...	...	...	9,139	...	...	...	9,139
Somerville	14-in.	...	...	...	...	...	115	...	...	115
Somerville	16-in.	...	...	...	...	...	...	403	...	403
Total	...	671	11,581	5,846	8,561	10,296	115	453	2,900	40,423

Extension of Distribution-Pipes.

LOCATION.	4-in.	6-in.	8 in.	10 in.	16-in.	Total.
Charlestown :						
Medford street		295				295
Tibbetts street		357				357
Baldwin street		295				295
Sheaf street	250					250
Mill court	124					124
Mitchell's court		184				184
Stark street		195				195
Carter street		190				190
Sewall's court		218				218
B. & M. R.R.	85	15				100
Chelsea bridge						
Chelsea		3,403				3,403
Everett :						
Broadway		93				93
Warren street	158					158
Winslow street		390				390
Lexington street		120				120
Fairmount street		425				425
Main street		330	73	84		487
Morris street		751				751
Hall ave.		396				396
Green street		328				328
Church street		377				377
Dean street	120					120
Garland street	580					580
Cleveland avenue		17				17
Tileston street		492				492
Williams street		133				133
Cross street		496				496
Wellington avenue			248			248
Clark street		280				280
West street	35		531			566
Avon street		529				529
Carried forward	1,352	10,309	852	84		12,594

Extension of Distribution-Pipes. — *Concluded.*

LOCATION.	4-in.	6-in.	8-in.	10-in.	12-in.	Total.
<i>Brought forward</i>	1,352	10,309	852	84	. . .	12,594
Buckman street		60			. . .	60
Garfield street		643			. . .	643
Bennett street		56			. . .	56
West End Railway	270	12			. . .	282
Prospect street		24			. . .	24
Willard street		24			. . .	24
Ferry street		72			. . .	72
Broadway court			24		. . .	24
Somerville	524	4,474	2,081	187	120	7,386
	2,146	15,674	2,957	271	120	21,165

Length of Distributing-Mains connected with Works, February 1, 1893.

DIAMETER.														
	3.in.	4.in.	6.in.	8.in.	10.in.	12.in.	14.in.	16 in.	18.in.	20.in.	24.in.	30.in.	36.in.	TOTAL.
Charlestown . . .	2,436	24,884	64,151	22,406	5,006	15,087		20,140		6,180	16,982	25,296	974	204,142
Somerville	7,455	91,118	169,240	41,179	11,268	9,154	8,037	120	387					337,958
Chelsea	18,313	77,014	42,373	7,787	26,653			2,348						174,488
Everett	914	52,744	64,527	4,930	7,128									130,243
Totals	29,118	2,457,611	340,291	76,392	50,655	24,241	8,037	22,608	387	6,180	16,982	25,296	974	846,831

Number of Gates connected with Works, February 1, 1893.

Charlestown . . .	13	166	216	58	17	37		25		4	11	12		559
Somerville . . .	5	225	314	27	22	23								616
Chelsea	30	179	64	22	19									314
Everett	4	105	170	15	12	2				2				310
Total	52	675	764	122	70	62		25		6	11	12		1,799

Hydrants Established.

	ESTABLISHED.				Net Increase.
	Lowry.	Boston Lowry.	Post.	Flush.	
Charlestown			4	.....	4
Somerville			62	.....	62
Chelsea			4	.....	4
Everett			37	.....	37
Total			107	.....	107

Total Number of Hydrants in use February 1, 1893.

Charlestown	198	33	58	38	327
Somerville	2	.....	627	.....	629
Chelsea . . . . .	.....	.....	188	2	190
Everett	1	.....	165	.....	166
Medford . . . . .	.....	.....	2	6	8
Pumping-station . . . . .	.....	.....	2	1	3
Total	201	33	1,942	47	1,223

Respectfully submitted,

EUGENE S. SULLIVAN,

Superintendent.

REPORT OF THE ENGINEER.

CITY OF BOSTON,
ENGINEERING DEPARTMENT,
50 CITY HALL, February 1, 1893.

MR. ROBERT GRANT, *Chairman Boston Water Board*:

SIR: I hereby submit the following report of the work done and records kept during the past year, for your Board:

SOURCES OF SUPPLY.

The rainfall during the past year was the smallest since 1883, and the percentage collected was also unusually small. The storage in the several lakes and reservoirs was gradually reduced during the summer and fall months until November, when all fears of a short supply were removed by the large rainfall during that month.

The rainfall and quantities collected on the several watersheds were as follows:

	Sudbury.	Cochituate.	Mystic.
Rainfall in inches .	41.83	39.04	39.115
“ collected in			
inches .	16.456	15.35	15.98
Daily average yield			
of water-shed, gal-			
lons . . .	58,753,000	13,753,500	20,390,700

The quality of the water from all the supplies has been as good as usual, and the supply from Sudbury river is gradually being improved.

The condition of the different reservoirs during the year is given below.

Reservoir No. 1. — Water was wasting at the dam from January 3 to April 15, and from May 12 to June 7.

No water was wasted for the balance of the year, except during six days in November and ten days in December, other than the daily flow of one and a half million gallons required by law.

The dam is in good condition.

Reservoir No. 2. — Water was flowing over the dam

almost constantly from January 4 to July 10. From this date till August 18 the surface of this reservoir was gradually lower, and at the latter date was at grade 161.36, or 5.76 feet below the top of the flash-boards.

During the balance of the year the surface of this reservoir rose and fell, reaching its lowest point on November 10, when it was 7.58 feet below the top of flash-boards; on January 1, 1890, it was 4.08 below.

The dam of Reservoir 2 is in good condition.

Reservoir No. 3. — The water in this reservoir was 8.05 feet below the crest of the dam on January 1, but was flowing over the crest on January 18, and continued to do so almost constantly until the last of June. From this date the surface gradually fell until August 26, when it was 6.20 feet below the crest of the dam. This was the lowest point reached during the year. On January 1, 1893, it stood at grade 171.58, or 3.66 feet below the crest of the dam. The dam of this reservoir is in good condition.

Reservoir No. 4. — The surface of the water in this reservoir was 6.36 feet below the crest of the dam, on January 1, but had filled to overflowing on January 21, and continued in this condition until August 16, when the gates were opened to furnish a portion of the supply for the city. From this date the water gradually fell to grade about 185.34, or 28.87 feet below the crest of the dam, when the outlet gate was closed. On January 1, 1893, the water had risen to grade 194.22, or 19.99 feet below the crest of the dam. The dam at Reservoir 4 is in good condition.

Farm Pond. — The water in this pond has been kept at an average height of 148.92 above tide marsh level. The conduit through the pond was used all the year except from May 14 to July 20, and from August 18 to August 30, when the supply was drawn through the pond.

The Framingham Water Company has pumped 82,800,000 gallons from the pond, an average of 226,200 gallons per day.

Lake Cochituate. — On January 1 the water in this lake was 7.02 feet below high-water mark, and the lake did not fill until May 4. Water was wasting at dam on May 20 to 24, and May 26 to 28, inclusive.

The lake continued near high-water mark until the latter part of June when it began to fall and continued to do so with great regularity until November 13, when it was 6.80 feet below high-water mark.

The lowest point reached was on December 8, when it was 6.91 feet below high water.

No water was drawn from the lake after December 10, and

on January 1, 1893, the surface was at grade 128.41, or 5.95 feet below high water. The dams are in good condition.

Water has been drawn from the different reservoirs as follows :

RESERVOIR No. 1.

January 9 to 11, inclusive.	February 25 to 28.
January 14 to 17.	March 3 to 6.
January 22 to 24.	March 10 to 13.
January 28 to 30.	March 16 to 20.
February 4 to 7.	March 24 to 27.
February 11 to 14.	March 29 to July 19.
February 18 to 21.	

RESERVOIR No. 2.

January 1 to 5.	November 21.
August 26 to 27.	November 26 to 27.
September 1 to 9.	November 29.
September 13 to November 14.	December 9 to 10.
November 18.	December 13 to 17.

RESERVOIRS Nos. 2 AND 3.

July 20 to August 25.	November 23 to 25.
August 28 to 31.	November 30 to December 4.
September 10 to 12.	December 7 to 8.
November 5 to 17.	December 11 to 12.
November 19 to 20.	

The heights of water in the various storage reservoirs on the first day of each month are given below :

		RESERVOIRS.				FARM POND.	LAKE COCHITU- ATE.
		No. 1.	No. 2.	No. 3.	No. 4.		
		Top of Flash- boards.	Top of Flash- boards.	Crest of Dam.	Crest of Dam.		
		159.29	167.12	175.24	215.21	149.25	134.36
January 1,	1892	157.20	163.55	167.19	207.85	148.99	127.34
February 1,	"	157.86	166.10	175.49	214.42	148.50	130.09
March 1,	"	158.00	166.15	175.58	214.49	148.65	130.27
April 1,	"	157.95	166.23	175.64	214.56	149.14	132.75
May 1,	"	155.72	167.21	175.05	214.78	149.00	134.17
June 1,	"	159.54	167.69	175.57	214.58	149.21	134.23
July 1,	"	156.84	167.38	174.89	215.31	149.45	133.83
August 1,	"	156.70	162.63	171.94	214.43	149.05	132.23
September 1,	"	156.35	164.79	169.60	210.55	148.95	130.84
October 1,	"	156.39	165.83	169.88	199.68	148.89	129.51
November 1,	"	156.22	159.70	170.14	187.40	148.55	127.98
December 1,	"	157.60	165.71	173.51	190.66	148.81	127.75
January 1,	1893	157.44	163.04	171.58	194.22	148.63	128.41

AQUEDUCTS AND DISTRIBUTING RESERVOIRS.

The Sudbury-river aqueduct has been used 322 days, and the Cochituate has been used 342 days, conveying water to the distributing reservoirs. The former has delivered 9,633,200,000 gallons into Chestnut-hill and Brookline reservoirs, equal to a daily supply of 28,800,000 gallons; and the Cochituate aqueduct has delivered 5,464,800,000 gallons, or 14,930,000 gallons per day. For 44 days the Sudbury aqueduct has also conveyed water to Lake Cochituate, delivering 902,400,000 gallons into the lake.

A nearly uniform depth of six and one-half feet was maintained in the Cochituate aqueduct while in use. The aqueduct was not used after December 10, on account of excavations under it by the city of Newton.

The rate of flow in the Sudbury aqueduct was varied from day to day to maintain the desired depth of water in the distribution reservoirs. Both aqueducts were cleaned as usual during the year.

The Chestnut-hill, Brookline, Fisher-hill, Parker-hill,

Cost per million gallons raised one foot high, \$0.049.

Cost per million gallons pumped to reservoir, \$6.15.

At the West Roxbury pumping-station, 33,588,675 gallons have been pumped, or a daily average of 91,800 gallons, an increase of 39.1 per cent. over the amount pumped in 1891.

At the East Boston pumping-station an average of 18,400 gallons per day has been pumped into Breed's island water-tower, an increase of 36.3 per cent. over the amount pumped in 1891.

Since July 22 water has been pumped daily into the East Boston reservoir during the day time to furnish an additional head for the high-service district. The check-valve with by-pass, against which the pumps work, is weighted to give about 20 pounds additional pressure on the mains while pumping. About 400,000 gallons were pumped daily for this service.

The small pump that was formerly used at the Brighton pumping-station is badly worn, and requires a good deal of attention to keep it in running order. The two larger pumps can be maintained in good condition with ordinary repairs.

MYSTIC LAKE.

Water was wasted over the dam almost constantly from January 14 to June 7, and from June 27 to July 7. From this date the surface of the lake gradually fell until it was 6.72 feet below high water on November 1; this was the lowest point reached during the year.

During November it filled to within 2.70 feet of high water, and on January 1, 1893, the lake was eighteen inches below high-water mark. The pumps were placed in position to pump water into the conduit in October, but the November rains raised the level of the lake before it became necessary to use them.

One of rain-gauges used in the calculation of the yield of the water-shed was moved from Symmes Corner to the north reservoir, Winchester, on September 1.

MYSTIC VALLEY SEWER.

The pump was run 346 days during the year, working 6,142 $\frac{2}{3}$ hours, and has pumped 134,576,100 gallons of sewage, an average of 389,500 gallons per day of pumping.

The amount pumped is 12.9 per cent. more than was pumped in 1891.

The total amount of sulphate aluminum used during the year was 338,065 lbs., and 182.9 tons of coal were used in pumping.

MYSTIC CONDUIT AND RESERVOIR.

The conduit is in good condition, except that a new gate should be placed on the blow-off pipe.

Both divisions of the reservoir were cleaned in June. The brick paving on the slopes was found to be in better condition than it was at the time of the previous cleaning, and but few repairs were necessary.

There are serious objections to the method now used for cleaning the reservoir, and to remedy it a drain should be laid to the Mystic river, through which the deposits that collect in the reservoir can be flushed; or sufficient time should be allowed for the deposits to dry, so that they can be hoisted over the banks.

If the flushing method be continued, the concrete bottom of the reservoir should be renewed, as it is now badly disintegrated. I renew the recommendation that new sills and grooves for the screens be placed in the screen-chamber, and that the roof of the chamber be raised to facilitate the changing of the screens.

MYSTIC PUMPING-STATION.

The increased consumption has required that in addition to the 8,000,000-gallon pump, one of the smaller pumps be run several hours nearly every day, thus reducing the duty obtained in 1891.

The running of Pumping-engine No. 1, which was built in 1864, is neither satisfactory nor economical; the pump has outlived its usefulness. New fronts have been placed on boilers Nos. 1, 2, and 3, and the Lamprey attachment for heating the feed-water has been placed inside the fire doors.

I renew the recommendations made in the last report, which have not been carried out.

Engine No. 1 was in use	669 $\frac{1}{4}$	
hours, pumping	.	131,022,700 gallons.
Engine No. 2 was in use	3,897 $\frac{3}{4}$	
hours, pumping	.	799,198,200 "
Engine No. 3 was in use	8,042 $\frac{1}{2}$	
hours, pumping	.	2,666,495,500 "
Total amount pumped	.	3,596,716,400 "
Total amount coal consumed	.	7,873,000 pounds.
Percentage ashes and clinkers	.	10.2
Average lift in feet	.	148.84
Quantity pumped per lb. of coal	.	456.8 gallons.
Average duty of engines per 100 lbs. of total coal, no deduction	.	56,709,000 ft. lbs.

Daily average amount pumped 9,827,100 gallons.

The amount pumped was an increase of 8.8 per cent. over that of 1891.

COST OF PUMPING.

Salaries	\$9,613 93
Fuel	14,294 22
Repairs	511 09
Oil waste and packing	744 51
Small supplies	348 44
Total	\$25,512 19

Cost per million gallons raised one foot high \$0.048

Cost per million gallons pumped to reservoir 7.09

The table on page 171 shows in detail the work done by the pumping-engines during the year.

CONSUMPTION.

The daily average consumption for 1892, and a comparison with that of 1891, is shown by the following table :

1892.	COCHITUATE.		MYSTIC.		COMBINED SUPPLIES.	
	Consumption in Gallons.	Percentage of Consumption, 1891.	Consumption in Gallons.	Percentage of Consumption, 1891.	Consumption in Gallons.	Percentage of Consumption, 1891.
January	36,756,400	98.7	9,878,200	105.2	46,634,600	100.0
February	38,881,500	104.3	10,332,200	109.1	49,213,700	105.3
March	38,395,100	108.1	9,970,500	113.2	48,365,600	109.1
April	37,171,000	104.0	9,145,000	113.7	46,316,000	105.8
May	37,055,900	101.3	9,204,900	104.1	46,260,800	101.8
June	41,564,000	109.9	10,146,300	107.0	51,710,300	109.4
July	45,738,100	117.1	10,702,900	111.7	56,441,000	116.0
August	45,031,600	114.1	9,751,500	106.9	54,783,100	112.8
September	45,261,000	111.3	9,549,400	104.6	54,810,400	110.0
October	44,626,700	114.9	9,340,500	100.9	53,967,200	112.2
November	41,347,800	112.8	9,230,000	107.5	50,577,800	111.8
December	43,766,400	118.3	10,473,700	116.9	54,240,100	117.1
Average	41,312,400	109.6	9,810,800	108.3	51,123,200	109.4

The daily average consumption per head of population was as follows :

Sudbury and Cochituate supply	95.3	gallons.
Mystic supply	78.6	“
Combined supplies	91.6	“

The above figures show an increase of 9.6 per cent. in the consumption from the Sudbury and Cochituate works from that of the previous year; of 8.3 per cent. increase in the consumption for the Mystic Works, and of 9.4 per cent. increase for the combined supplies.

DISTRIBUTION.

The total length of main pipe laid on the Cochituate division was nearly 18 miles, and 4,270 feet of pipe have been abandoned, making a net increase of a little more than 17 miles in the total length in use.

Only about 1,500 feet of pipe were relaid with larger sizes to improve the fire service, and I recommend that at least one mile of the old mains be relaid this year for that purpose.

The laying of the 30-inch main to South Boston was completed on May 27th.

This main connects with the 30 and 36 inch mains in Tremont street at West Chester, park and extends through Chester park and Swett street to Washington Village, a distance of 7,600 feet, connecting with the 20-inch main in Boston street.

A spiral weld steel pipe was used for crossing the sluices in Swett street; the pipe being reduced to 24 inches in diameter at the two bridges, which are considered to be temporary structures.

A 6-inch pipe was laid from Squantum to supply the Asylum and Farm School on Thompson's island. The work was done by John Cavanagh & Co., who were the lowest bidders. The length of the pipe was 6,760 feet, 300 feet under the channel between Squantum and the island being laid with the Ward flexible-jointed pipe. Water was turned on in this pipe July 5.

Water-pipes were laid from the pipe on Long island to the hospitals on Gallop's island in the fall; 2,874 feet of 6-inch pipe on Long island and 991 feet of 6-inch pipe on Gallop's island were laid by John Cavanagh & Co., under a contract. A temporary 3-inch wrought-iron pipe 3,798 feet in length, on the bottom of the channel between the

islands was laid by George W. Townsend, under a contract. The pipe was put together with screw couplings by divers and was laid in two weeks' time. The temporary pipe was paid for by the Board of Health.

The sea-water has been so unusually cold that the 6-inch pipe between Moon and Long islands was frozen, after having successfully passed through four winters without accident. The pipe is encased in a wooden box of $3\frac{1}{2}$ -inch plank and is buried in a trench where there is less than 10 feet of water over the pipe at low tide. The freezing probably began in deep water, as the water in the bay was only 28 degrees above zero.

In Charlestown the mains were extended 2208 feet, and 216 feet of 4-inch pipe were relaid with 6-inch pipe.

ADDITIONAL SUPPLY.

The development of the Sudbury system has been continued during the past year. The work of building the basin on Indian brook (Basin No. 6) has made fair progress, and it will be so far advanced at the end of the present season that the basin can be put into service. The surveys for additional basins have been nearly finished, and their construction must be commenced at once, as the increasing consumption of water by the city has more than kept pace with development of the water supply, and even with Basin No. 6 the works have barely sufficient capacity in a dry year to supply the present consumption.

For particulars, see the following report of Desmond FitzGerald, Resident Engineer:

SOUTH FRAMINGHAM, MASS. January 30, 1893.

WILLIAM JACKSON, Esq., *City Engineer*:

SIR: I submit herewith a brief report of engineering work accomplished during the past year by the Additional Supply force.

At Basin No. 6 the core-wall was uncovered early in April, and on April 25 the first gravel was delivered on the dam. Work on the shallow flowage, stripping of basin, and building up of the dam was actively prosecuted throughout the season. The dam has been raised from grade 250 to 271, or 21 feet. Both gate-chambers have been built to grade. The valves have been placed in the lower gate-house. The wasteway has been completed. Excellent progress was made by the contractors in stripping the basin. Sections A, B, and C, which were let in 1891, have been completed and final estimates made. Section D is nearly finished. Section E, above the

Cordaville road, was let to John Berry & Co., on January 13, and is practically completed.

Mr. N. S. Brock, Assistant Engineer, has been in charge of Basin 6.

WORK DONE AT BASIN 6 DURING 1892.

Concrete	4,116 cubic yards.
Backfilling	148 " "
Plaster	2,140 square yards.
Embankment	126,726 cubic yards.
Loaming slope	1,572 " "
Riprap "	2,546 " "
Stone crushed	1,579 " "
Sand and gravel screened	1,521 " "
Stone masonry	256 " "
Brick "	143 " "
Stripping earth (contract)	321,516 " "
" " (city)	17,415 " "

WASTEWAY.

Earth excavation	3,000 " "
Rock	660 " "
Concrete	526 " "
Paving	747 square yards.
Rubble masonry	1,136 cubic "
Dimension masonry	102 cubic "
Coping	1,420 lineal feet.

During the winter of 1891-2 surveys for Basin 5, on Stony brook, were extended and a new plan made showing contours to grade 250, extending down stream as far as Nichol's mill.

A large amount of engineering work has been done on problems connected with Cedar swamp. After many trial lines, a line for the principal canal has been located and plans perfected for all details of construction.

In May, studies were begun for a basin on the site of this swamp. This involves raising the B. & A. R.R. between Chattanooga and Westboro', and extensive excavations of mud. Plans and approximate estimates have been prepared.

Very truly yours,

(Signed)

DESMOND FITZGERALD,

Resident Engineer.

SEWERAGE SYSTEMS.

South Framingham, Marlboro', Westboro', Natick.

The sewerage system of South Framingham has, with the exception of the discharging from the town underdrain, worked satisfactorily. The city of Marlboro' and the town of Westboro' have so far completed their sewer system as to have them in successful operation.

The town of Natick has made a plan of works and seems to be in earnest to do something this year.

FILTRATION OF THE MYSTIC SUPPLY.

Although the quality of the water furnished by the Mystic works has been comparatively good during the past year, the large and increasing population on the water-shed, together with the objectionable character of the large number of factories on the borders of the streams, renders the task of maintaining the purity of the water a more difficult one from year to year; and in case of an epidemic of cholera or typhoid fever in Winchester or Woburn, there would be great danger in using the Mystic water unless it was thoroughly filtered.

If the Mystic works are to be continued in use as a source of supply for ten years, and I can see no way by which they can be abandoned before that time, I am of the opinion that a filtration plant should be at once constructed.

Judging from the results of the experiments of the State Board of Health and of your Board, I can see no reason why, if this is done, these works should not furnish water of satisfactory quality.

With this end in view, surveys and estimates have been made of the cost of works capable of filtering the entire Mystic supply.

The scheme of works as planned comprises seven filtering basins, each having an area of about one acre, to be built on the shore of the lake, near the present dam, with a pumping-station and engines to raise the water from the lake to the filter basins.

The estimated cost of these works is \$575,000.

CAPACITY OF DISTRIBUTION SYSTEM.

In accordance with a vote of your Board, dated January 27, 1892, an investigation has been made of the capacity of the distribution system, considered with reference to the water supply available for fire protection, and comparisons have

been made with the distribution systems of other large cities in the United States.

Connected with the Sudbury and Cochituate works, there were, January 1, 1892, 514.4 miles of supply and distributing mains, of which 468 miles are of sizes from 4 inches to 16 inches in diameter, and may be properly termed the distributing mains. The remaining 46.4 miles consist of main pipes from 20 inches to 48 inches in diameter, which are not tapped for service-pipe or fire-hydrant supplies.

From the Chestnut-hill and Brookline reservoirs the water is brought to the city, a distance of about four miles, by four mains, 30-inch, 36-inch, 40-inch, and 48 inches in diameter.

These mains will supply in the city, with a pressure of 40 pounds to the square inch, at least 100 cubic feet per second, which is equivalent to an ample supply for 100 steam fire-engines.

Since the great fire of November 9, 1872, the distribution system of Boston has been greatly improved by the relaying of about 40 miles of 4 and 6-inch mains, with others of much greater capacity, and also by the introduction of larger and improved patterns of hydrants.

Throughout the business portion of the city, 16-inch, 12-inch, 10-inch, and 8-inch pipes are extensively used; the proportion of these sizes being about 45% of the total distribution.

Throughout the mercantile section of the city, embracing the district bounded by Washington street, State street, Broad street, Atlantic avenue, Federal street, and Beach street, a system of water supply is provided for fire protection, in addition to the supply afforded by the hydrants connected with the low-service distribution pipes, by a separate system of distribution-pipes to be laid throughout this district for the sole purpose of supplying water under high pressure (80 to 90 pounds) to stand-pipes and sprinkler systems in the buildings of the district. This enables the property-owners in this district to provide themselves with a water supply for fire protection, which is available at all times, and which will not be affected by the drafts which are made by the fire department from the hydrants.

In the residential districts, the pipes are somewhat smaller, and in the suburban sections of Dorchester, West Roxbury, and Brighton the capacity of the distribution system for fire protection is, as must be expected, much smaller than in the more thickly settled portions of the city.

Connected with the distributing mains there were 5,682 hydrants, and 238 reservoirs for use in case of fire.

Four styles of hydrants are used, viz., the Boston, the Lowry, the Boston Lowry, and the Post.

The Boston hydrant is the pattern exclusively used from 1848 to 1868. It has a barrel three inches in diameter, with a single $2\frac{1}{2}$ -inch outlet, and is supplied by a branch pipe from the main 4 inches in diameter.

The hydrants of this pattern are being gradually replaced by others of greater capacity.

The Lowry hydrant, of which there were 2,449 in use, has a 9-inch barrel, and is arranged to supply four steam fire-engines, by means of a portable chuck having two $2\frac{1}{2}$ -inch and two 4-inch outlets, each outlet being provided with a separate valve.

Hydrants of this pattern are generally placed directly over the supplying main, and at the junction of connecting pipes. When placed in the sidewalk they are supplied by 9-inch or 12-inch branches from the mains.

The Boston Lowry hydrant has a 6-inch barrel, and is supplied by a 6-inch branch pipe from the main. This hydrant is generally placed in narrow sidewalks where the Post hydrant would inconvenience public travel. Four steamers can be attached to this hydrant, but when set in the sidewalk it is not often convenient to attach more than two steamers.

The Post hydrant has a six inch barrel supplied by a 6-inch branch pipe, and has one 4-inch and two $2\frac{1}{2}$ -inch outlets.

As previously stated, the hydrants used from 1848 to 1868 had 3-inch barrels with a single outlet two $2\frac{1}{2}$ -inches in diameter, and at the latter date there were in use in the City Proper, South Boston, and East Boston, 1,590 hydrants of this pattern.

During the past twenty years a large number of these old hydrants have been replaced by hydrants of the Lowry and Post patterns, so that to-day the number of "Boston" hydrants in use in the City Proper, South Boston, and East Boston, is 660 less than in 1869.

Throughout the business portion of the city the hydrants are spaced from 150 to 250 feet apart, and from 250 to 300 feet in the residential districts.

Below are given extracts from the report of Mr. Dexter Brackett, Assistant Engineer, who visited the larger cities of the country and made a personal examination of their distribution systems.

"A comparison of the distribution system of Boston with those of the other large cities of the country shows that the system here is not behind the modern practice in the matter of fire protection.

"As a result of a personal examination of the systems in New York, Brooklyn, Philadelphia, Baltimore, Washington, Pittsburgh, Cincinnati, St. Louis, Chicago, Detroit, and Cleveland, the following tables and accompanying plans have been prepared.

"The plans in all cases cover the thickly settled business portions of the cities.

"Table No. 1 shows the length in miles of the different sizes of pipe in use in the cities named, and table No. 2 gives for each city the percentage used of the different sizes : —

TABLE I.
Miles of Pipe of Different Sizes in Use in some of the Large Cities of the United States, January, 1892.

	3-in.	4-in.	4½-in.	6-in.	8-in.	10-in.	12 in.	14-in.	15-in.	16-in.	18-in.	20-in.	24-in.	30-in.	36-in.	40-in.	42-in.	46-in.	48-in.	Total Miles.
New York	. . .	6.2	. . .	422.6	. . .	1.2	168.4	. . .	. . .	3.2	. . .	37.9	2.2	7.9	21.6	. . .	. . .	. . .	14.3	685.5
Chicago	3.2	203.9	. . .	560.8	242.1	5.1	78.9	3.3	. . .	36.8	. . .	1.7	33.9	1.0	14.3	. . .	. . .	. . .	0.3	1205.3
Philadelphia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1001.6
Brooklyn	. . .	0.7	. . .	286.3	77.9	. . .	35.9	. . .	. . .	2.1	. . .	19.7	. . .	6.4	8.9	. . .	. . .	. . .	12.1	450.0
St. Louis	11.9	1.9	. . .	239.1	10.5	9.8	40.9	. . .	10.2	. . .	. . .	25.8	. . .	7.1	10.6	. . .	. . .	. . .	0.2	368.0
Boston¹	. . .	21.0	. . .	216.0	59.5	8.3	147.0	. . .	. . .	13.2	. . .	11.3	11.0	10.9	4.0	4.4	. . .	. . .	4.8	514.4
Baltimore	108.7	126.6	13.8	64.2	6.3	35.8	11.7	. . .	. . .	7.2	1.2	22.1	. . .	10.5	5.3	7.4	. . .	. . .	. . .	420.7
Cincinnati	11.1	91.7	. . .	85.9	12.6	45.6	3.9	. . .	. . .	6.3	. . .	17.9	1.2	0.1	4.8	0.7	. . .	0.7	0.1	282.6
Cleveland	2.7	23.9	. . .	187.4	58.0	21.0	5.7	. . .	. . .	5.4	. . .	3.3	2.9	14.5	7.9	. . .	. . .	. . .	. . .	333.3
Pittsburgh	. . .	52.0	. . .	95.6	23.4	6.0	10.6	0.3	7.0	1.0	. . .	8.0	1.8	5.2	6.3	. . .	. . .	. . .	0.7	217.9
Washington	5.5	21.0	. . .	142.0	1.1	2.3	14.5	. . .	. . .	. . .	. . .	3.8	0.5	6.2	4.3	. . .	. . .	. . .	5.6	209.8
Detroit	15.9	150.3	. . .	135.1	55.8	18.3	0.7	. . .	. . .	4.9	. . .	0.1	13.9	9.3	0.1	. . .	8.5	. . .	. . .	392.9

¹ These figures are for January, 1892, to compare with data from other cities.

TABLE II.
Percentage of the Different Sizes of Pipe Used, January, 1892.

	3-in.	4 in.	4½-in.	6 in.	8-in.	10-in.	12-in.	14-in.	15-in.	16-in.	18-in.	20-in.	24-in.	30-in.	36-in.	40 in.	42-in.	46-in.	48-in.	Percentage less than 6 in.	Percentage less than 8-in.
New York	. . .	0.9	. . .	61.6	. . .	0.2	24.6	. . .	. . .	0.5	. . .	5.5	0.3	1.2	3.1	. . .	. . .	. . .	2.1	0.9	62.5
Chicago	0.3	16.9	. . .	48.2	20.1	0.4	6.5	0.3	. . .	3.1	. . .	0.1	2.8	0.1	1.2	. . .	. . .	. . .	. . .	17.2	65.4
Philadelphia																					
Brooklyn	. . .	0.2	. . .	63.6	17.3	. .	8.9	. . .	. . .	0.4	. . .	4.4	. .	1.4	2.0	. . .	. . .	. . .	2.7	0.2	63.8
St. Louis	3.2	0.5	. . .	65.0	2.9	2.7	11.1	. . .	2.8	. . .	. . .	7.0	. .	1.9	2.9	. . .	. . .	. . .	. . .	3.7	68.7
Boston	. . .	4.7	. . .	42.0	11.6	1.6	28.6	. . .	. . .	2.6	. . .	2.2	2.1	2.1	0.8	0.5	. . .	. . .	0.9	4.7	46.7
Baltimore	25.8	30.1	3.3	15.3	1.5	8.5	2.8	. . .	. . .	1.7	0.3	5.2	. .	2.5	1.2	1.8	. . .	. . .	. . .	55.9	74.5
Cincinnati	3.9	32.4	. . .	30.4	4.5	16.1	1.4	. . .	. . .	2.2	. . .	6.3	0.4	0.1	1.7	0.2	. . .	0.2	0.1	36.3	66.7
Cleveland	0.8	7.2	. . .	56.2	17.4	6.5	1.7	. . .	. . .	1.6	. . .	1.0	0.9	4.3	2.4	. . .	. . .	. . .	. . .	8.0	64.2
Pittsburgh	. . .	23.9	. . .	43.9	10.8	2.7	4.8	0.1	3.2	0.5	. . .	3.7	0.8	2.4	2.9	. . .	. . .	. . .	0.3	23.9	67.8
Washington	2.6	11.4	. . .	67.7	0.5	1.1	6.9	. . .	. . .	. . .	. . .	1.8	0.2	3.0	2.1	. . .	. . .	. . .	2.7	14.0	81.7
Detroit	4.0	38.3	. . .	34.4	9.1	4.7	0.2	. . .	. . .	1.2	. . .	. . .	3.5	2.4	. .	. . .	2.2	. . .	. . .	42.3	76.7

" Bearing in mind the fact that pipe less than six inches in diameter is of very little value for fire protection, a study of the tables shows very clearly the comparative value of the different systems. It will be noticed that the proportion of the sizes below eight inch is less in Boston than in any of the cities examined.

" Baltimore has 235 miles, or more than one-half of its distribution system of 3 and 4-inch pipe; Chicago has 207 miles, Detroit 166 miles, and Cincinnati 103 miles, while Boston has but 24 miles. On the other hand, Boston has 147 miles of 12-inch pipe, the proportion of this size being larger than in any of the other cities.

" The efficiency of a system for fire protection depends not only upon the size of the mains, but also on the number and capacity of the fire hydrants connected with those mains. If, as in some of our large cities, the hydrants used are of small capacity with a single outlet, allowing of but one steamer connection and spaced from 300 to 500 feet apart, the efficiency of the system is much diminished by the inability to concentrate a large number of steamers near any given point. To perform effective service, a steamer should not be obliged to use more than 500 feet of $2\frac{1}{2}$ -inch hose to reach the fire. With a line of hose 600 feet in length a water-pressure of 120 pounds at the steamer will give an effective fire stream about 60 feet above the ground and will discharge 240 gallons per minute, while with 100 feet of hose the same pressure would give an effective stream of 94 feet in height and discharge 340 gallons per minute.

" It is, therefore, of great advantage to have hydrants of large capacity so located that a large number of steamers may be placed within a short distance of the fire.

" The Lowry hydrant, used in Boston, being located in the centre of streets and provided with outlets for four steamer connections, permits of the concentration of the steamers much better than any other hydrant in general use. At the Bedford-street fire on Nov. 28, 1889, fifty-two steamers were in service and none were located more than 600 feet from the fire. In Brooklyn and St. Louis the hydrants have but one outlet or hose connection.

" In New York 80 per cent. of the hydrants have but one $2\frac{1}{2}$ -inch outlet, and all of the hydrants set there during the past year, 1891, were of this pattern. Table No. 3 shows the number of hydrants and fire reservoirs in use in the different cities with the number and size of hose connections.

TABLE No. III.
No. of Hydrants and Fire Reservoirs in Use in Different Cities.

NUMBER AND DIAMETER OF HYDRANT NOZZLES.															Fire Reservoirs Connected with Mains.	Total number of Hydrants and Reservoirs.	Hydrants per Mile of Distribution.	Total Number of Hydrant Nozzles.	Hose Connection per Mile of Pipe.
1 2-in.	1 2½-in.	1 3-in.	1 4-in.	2 2½-in.	2 3-in.	1 2½-in. 1 4-in.	2 2½-in. 1 4-in.	2 4-in.	3 2½-in.	1 2½-in. 2 4-in.	2 2½-in. 2 4-in.								
	6,825					1,927								8,752	12.8	10,679	15.6		
New York ..														87	11,923	9.9	23,397	19.4	
Chicago ..		2,739			6,328		2,203	566											
Philadelphia ..		3,696		1,032				2,408							8,105	8.1	12,451	12.4	
Brooklyn ..		4,538													4,538	10.1	4,538	10.1	
St. Louis ..															3,715	10.1	3,715	10.1	
Boston ..		1,191												238	5,920	11.5	18,402	35.8	
Baltimore ..															1,359	3.2	4,077	9.7	
Cincinnati ..			1,530			223								300	2,053	7.3	2,876	10.2	
Cleveland ..	200				3,490		134								3,824	11.5	7,582	22.7	
Pittsburgh ..		500		986				250							1,736	8.0	1,986	9.1	
Washington ..					300				600	300					1,200	5.7	3,300	15.7	
Detroit ..				1,768					200					439	2,407	6.1	3,485	8.9	



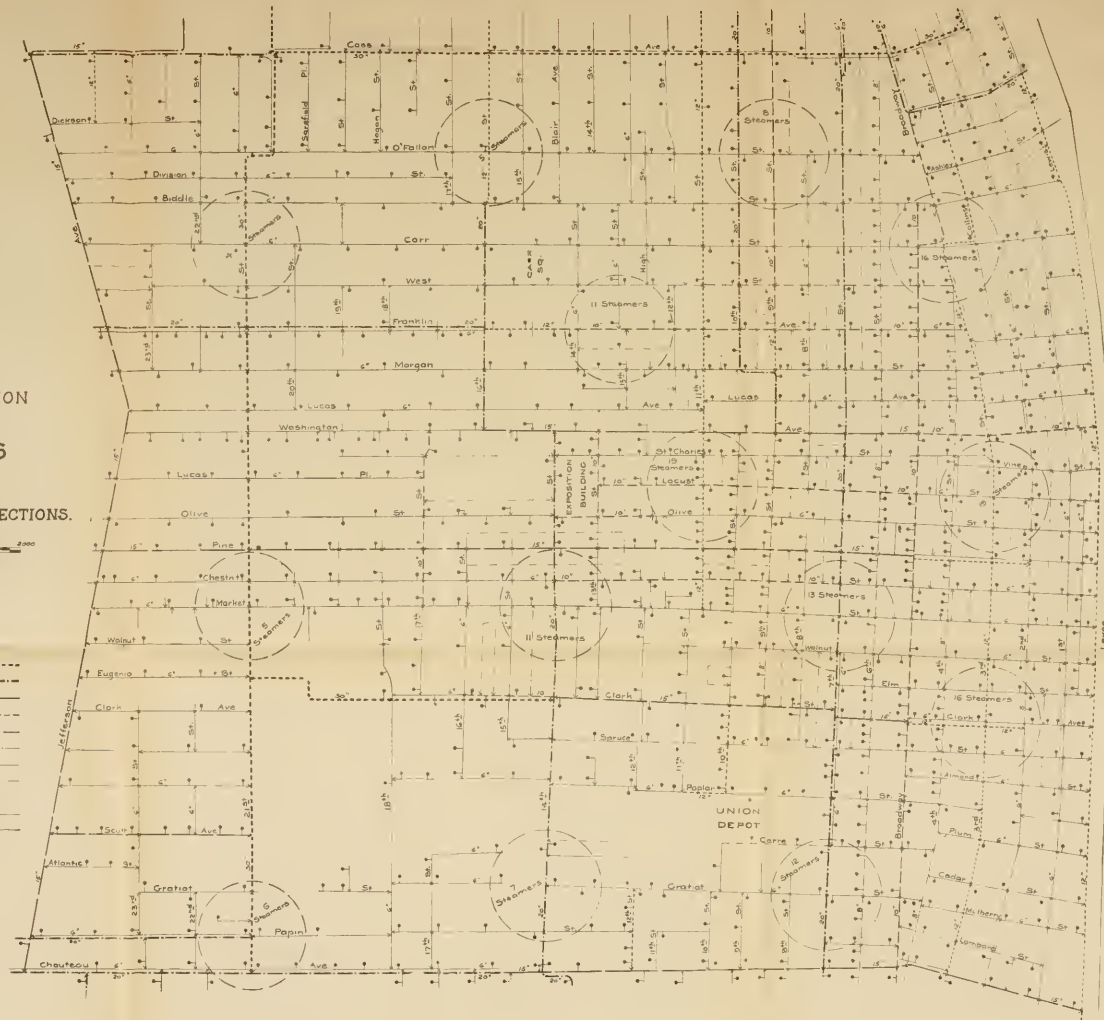
COMING
ARROW POINT



PLAN OF A PORTION
OF
ST. LOUIS
SHOWING
PIPE LINES, HYDRANTS & CONNECTIONS.

SCALE OF FEET
0 100 200 300 400
APRIL, 1892.

30 inch pipe shown thus -----
20 " -----
15 " -----
12 " -----
10 " -----
8 " -----
6 " -----
4 " -----
3 " -----
Connections -----
Hydrants -----



RIVER

MISSISSIPPI

PLAN OF A PORTION
OF
ST. LOUIS

SHOWING

THE LINES, HYDRAULIC & EXHAUSTION

APRIL 1891





PLAN OF A PORTION

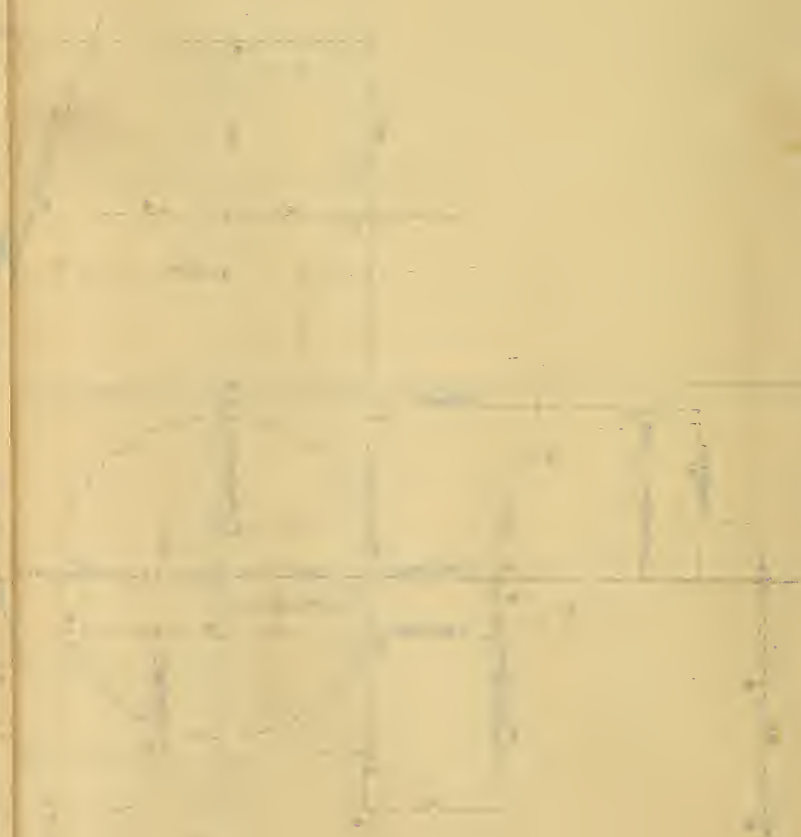
OF THE

CITY OF BALTIMORE

SHOWING

PIPE LINES, HYDRAULIC & CO.

JAN 1888



PLAN OF A SECTION OF THE CITY OF PHILADELPHIA,

—SHOWING—
PIPE LINES, HYDRANTS & CONNECTIONS.

SCALE OF FEET
0 100 200 300 400 500

JAN. 1892.

TWO SHEETS.
SHEET No. 1.

48 inch pipe shown thus	----
36 " " " " " "	-----
30 " " " " " "	-----
22 " " " " " "	-----
20 " " " " " "	-----
16 " " " " " "	-----
12 " " " " " "	-----
10 " " " " " "	-----
8 " " " " " "	-----
6 " " " " " "	-----
4 " " " " " "	-----
3 " " " " " "	-----
Connections	-----
Hydrants, Single Nozzle	-----
Double	-----
Three	-----



173

MO

PLAN OF A
PHIL

PIPE LINES, HYI

W

SCH

12 10 10

10 10

10 10

10 10







RIVER

ETAS





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"As before stated, the sizes of the mains and the number and capacity of the hydrants are all factors in determining the value of any distribution system as a means of fire protection.

"Taking all of these facts into consideration, a study has been made of the corresponding portions of the systems of several cities as shown on the accompanying plans.

"Calculations have been made as to the number of steamers that will receive an ample supply of water from hydrants located within 500 feet of various points. The points selected and the results attained for each city are shown by the following tables and by the figures enclosed by circles on the plans :

"Tables showing the number of hydrants and fire reservoirs located within 500 feet of different points in or near the business sections of the cities named, also the number of steamers, each of 500 gallons capacity, that would receive an adequate supply of water from those hydrants:

NEW YORK.

	Hydrants.	Res.	Steamers.
Canal street, junction Bowery . . .	35		62
Canal street, junction Broadway . .	31		47
Franklin street, junction West Broadway	25		44
Washington street, junction Chamber street	26		42
Prince street, junction Broadway . .	26		42
Church street, junction Park place .	24		41
Chamber street, junction Park row .	27		38
Christie street, junction Rivington street	23		35
Cherry street, junction Clinton street .	18		26
Grand street, junction Margin street .	16		26
Broome street, junction Clinton street .	15		17
Market street, junction Madison street .	12		12
Pearl street, junction Peck street .	11		12
Spring street, junction Varick street .	10		10

CHICAGO.

Randolph street, junction Wabash ave. .	11	4	32
Adams street, junction La Salle street .	14	2	30
Wabash avenue, junction Adams street .	11	2	27
Van Buren street, junction Dearborn street	16		27
Lake street, junction Franklin street .	13	1	27

	Hydrants.	Res.	Steamer.
Madison street, junction Fifth avenue .	13	1	25
Ontario street, junction La Salle street .	14		25
Van Buren street, junction Franklin street	10	1	22
Randolph street, junction La Salle street,	11	1	22
Ontario street, junction Market street .	8	1	18
Union street, junction Indiana street .	10		17
Madison street, junction Jefferson street,	10		17
Ontario street, junction Pine street . .	9		14
Van Buren street, junction Jefferson street	9		13

ST. LOUIS.

Locust street, junction 11th street . .	19		19
Locust street, junction 3d street . .	19		19
Clark street, junction 3d street . .	16		16
Carr street, junction Broadway . .	16		16
Market street, junction 7th street . .	13		13
Gratiot street, junction 7th street . .	12		12
Market street, junction 14th street . .	11		11
Franklin street, junction 13th street . .	11		11
O'Fallon street, junction 9th street . .	8		8
Gratiot street, junction 14th street . .	7		7
Papin street, junction 21st street . .	6		6
Market street, junction 21st street . .	5		5
O'Fallon street, junction 16th street . .	5		5
Carr street, junction 21st street . .	4		4

BOSTON.

Washington street, junction State street .	24	4	60
Washington street, junction Essex street,	20	2	54
Washington street, junction Franklin street	19	2	51
Haymarket square	22	2	51
Franklin street, junction Pearl street .	20	1	50
Summer street, junction Federal street .	18		50
Hanover street, junction Fleet street .	21		49
Kneeland street, junction South street .	16		40
Washington street, junction Pleasant street,	18	2	36
Tremont street, junction Dover street .	14		36
Causeway street, junction Leverett street,	20	3	35
Pleasant street, junction Piedmont street,	18	3	28
Dover street, junction Harrison avenue .	12		26
Boylston street, junction Berkeley street,	11		25

BALTIMORE.

	Hydrants.	Res.	Steamer.
Calvert street, junction Baltimore street,	21		37
Liberty street, junction Baltimore street,	12		29
Calvert street, junction Franklin street,	11		25
Lombard street, junction Frederick street,	13		23
Camden street, junction Eutaw street,	8		16
Lombard street, junction Central avenue,	8		15
Gorman street, junction of Greene street,	7		12
Orleans street, junction Central avenue,	6		10
Fremont street, junction Portland street,	5		7

PHILADELPHIA.

Market street, junction 12th street .	14	23
Chestnut street, junction 16th street .	13	18
Spring Garden, junction 6th street .	15	18
Chestnut street, junction 5th street .	15	17
Market street, junction 2d street .	14	16
Spruce street, junction 12th street .	9	14
Walnut street, junction 22d street .	8	13
Poplar street, junction 27th street .	11	12
Vine street, junction 3d street .	11	12
Fairmount street, junction 10th street .	10	10
Fairmont street, junction 19th street .	10	10
Spruce street, junction 18th street .	8	10
Vine street, junction 11th street .	7	8
Vine street, junction 18th street .	7	7

BROOKLYN.

Fulton street, junction Flatbush avenue .	15	15
Fulton street, junction Adams street .	15	15
Nassau street, junction Adams street .	11	11
Hicks street, junction Peirrepoint street .	10	10
President street, junction Fifth avenue .	10	10
Seventh avenue, junction 9th street .	10	10
Court street, junction Congress street .	9	9
Bond street, junction Wykoff street .	9	9
Park street, junction North Portland street,	8	8
Hoyt street, junction Secor place .	7	7
Fulton street, junction Adelphi street .	6	6
Columbia street, junction President street	6	6
Sullivan street, junction Van Brunt street	5	5
Clinton street, junction Fourth place .	5	5."

A careful study of the facts given warrants the conclusion that Boston has as good if not a better system of water dis-

tribution for fire purposes than any of the other large cities of the country; that the Lowry hydrant in use here will supply more steamers than any other hydrant in general use, and that the Boston pattern of Post hydrant is of greater capacity than that used by many other cities.

Of the 1,200 old style hydrants and 24 miles of 4-inch pipe that are now in use about 50 per cent. should be replaced within a few years.

Appended are tables showing for all sections of the city the number of steamers that it is estimated would receive a supply of 500 gallons per minute each from hydrants located within 500 feet of the locations given. In considering these tables, it must be borne in mind that 500 gallons per minute provides for two efficient streams from each steamer, and as at any fire some steamers will be using but one line of hose, and others will be stopped at any given moment, the number of steamers, which under the usual circumstances, could be adequately supplied would be somewhat larger than the figures given.

CITY PROPER — BUSINESS SECTION.

Albany street, junction Canton street	26
Albany street, junction Concord street	27
Albany street, junction Dover street	25
Albany street, junction East Chester park	35
Albany street, junction Oak street	32
Albany street, junction Randolph street	16
Albany street, junction Union Park street	16
Albany street, junction Wareham street	32
Albany street, junction Way street	30
Atlantic avenue, junction Central wharf	35
Atlantic avenue, junction Clinton street	45
Atlantic avenue, junction Federal street	50
Atlantic avenue, junction India street	45
Atlantic avenue, junction Oliver street. . . .	40
Atlantic avenue, junction Pearl street	50
Beach street, junction Albany street	40
Beach street, junction Harrison avenue	40
Bedford street, junction Kingston street	50
Bowdoin square	33
Brattle square	50
Causeway street, junction Beverly street	25
Causeway street, junction Friend street	33
Causeway street, junction Leverett street	35
Chapman street, junction Shawmut avenue	22
Chapman street, junction Village street	26
Charlestown street, junction Beverly street	60

Charlestown street, junction Causeway street . . .	31
Columbus avenue, junction Berkeley street . . .	25
Columbus avenue, junction Ferdinand street . . .	24
Columbus avenue, junction Pleasant street . . .	30
Commercial street, junction Charter street . . .	24
Commercial street, junction Clinton street . . .	56
Commercial street, junction Fleet street . . .	48
Commercial street, junction North street . . .	48
Commercial street, junction Richmond street . . .	48
Commercial street, junction State street . . .	60
Court street, junction Sudbury street . . .	33
Eliot street, junction Carver street . . .	29
Federal street, near the bridge . . .	12
Federal street, junction East street . . .	35
Federal street, junction Kneeland street . . .	20
Ferdinand street, junction Melrose street . . .	20
Fort Hill square . . .	50
Franklin street, junction Congress street . . .	50
Hanover street, junction Cross street . . .	45
Hanover street, junction Fleet street . . .	49
Harrison avenue, junction Castle street . . .	30
Harrison avenue, junction Dover street . . .	26
Harrison avenue, junction Harvard street . . .	30
Harrison avenue, junction Oak street . . .	30
Haymarket square . . .	45
Kneeland street, junction Lincoln street . . .	40
Leverett street, junction Charles street . . .	29
Leverett street, junction Minot street . . .	40
Merrimac street, junction Chardon street . . .	35
Milk street, junction Oliver street . . .	50
North street, junction Cross street . . .	36
Piedmont street, junction Pleasant street . . .	25
Prince street, junction Salem street . . .	48
Prince street, junction Snowhill street . . .	28
Scollay square . . .	35
Travers street, junction Canal street . . .	32
Tremont street, junction Boylston street . . .	30
Tremont street, junction Castle street . . .	35
Tremont street, junction Eliot street . . .	33
Tremont street, junction Mason street . . .	20
Tremont street, junction Pleasant street . . .	33
Tremont street, junction School street . . .	15
Tremont street, junction Winter street . . .	15
Washington street, junction Bedford street . . .	40
Washington street, junction Boylston street . . .	48
Washington street, junction Castle street . . .	25
Washington street, junction Hanover street . . .	60

Washington street, junction Hollis street . . .	32
Washington street, junction Milk street . . .	55
Washington street, junction State street . . .	60
Washington street, junction Summer street . . .	43
Winthrop square	50

CITY PROPER — RESIDENTIAL SECTION.

Allen street, junction Blossom street . . .	24
Beacon street, junction Arlington street . . .	15
Beacon street, junction Charles street . . .	18
Beacon street, junction Chester park . . .	18
Beacon street, junction Exeter street . . .	14
Beacon street, junction Joy street . . .	15
Berkeley street, junction Chandler street . . .	16
Boylston street, junction Arlington street . . .	15
Boylston street, junction Berkeley street . . .	20
Boylston street, junction Clarendon street . . .	20
Boylston street, junction Exeter street . . .	20
Cambridge street, junction Blossom street . . .	30
Cambridge street, junction Hancock street . . .	27
Charles street, junction Allen street . . .	27
Charles street, junction Cambridge street . . .	17
Charles street, junction Revere street . . .	24
Clarendon street, junction Appleton street . . .	17
Columbus avenue, junction Clarendon street . . .	18
Columbus avenue, junction Dartmouth street . . .	19
Columbus avenue, junction Holyoke street . . .	20
Columbus avenue, junction Rutland square . . .	22
Columbus avenue, junction West Chester park . . .	19
Commonwealth avenue, junction Clarendon street . . .	12
Commonwealth avenue, junction Fairfield street . . .	20
Dalton street, junction Dundee street . . .	17
Dartmouth street, junction Buckingham street . . .	12
Harrison avenue, junction Dedham street . . .	35
Harrison avenue, junction Newton street . . .	30
Harrison avenue, junction Worcester street . . .	24
Huntington avenue, junction Dartmouth street . . .	24
Huntington avenue, junction Gainsborough street . . .	18
Huntington avenue, junction Holyoke street . . .	13
Huntington avenue, junction Newton street . . .	18
Marlborough street, junction Berkeley street . . .	18
Marlborough street, junction Dartmouth street . . .	14
Marlborough street, junction Hereford street . . .	26
Mt. Vernon street, junction Brimmer street . . .	20
Mt. Vernon street, junction Louisburg square . . .	18
Myrtle street, junction Grove street . . .	18

Myrtle street, junction Irving street	15
Shawmut avenue, junction Chester square	20
Shawmut avenue, junction Concord street	18
Shawmut avenue, junction Lenox street	12
Shawmut avenue, junction Newton street	24
Shawmut avenue, junction Union park	21
Somerset street, junction Ashburton place	15
Tremont street, junction Camden street	26
Tremont street, junction Clarendon street	20
Tremont street, junction Dartmouth street	27
Tremont street, junction Pembroke street	25
Tremont street, junction Worcester street	20
Warren avenue, junction Dartmouth street	18
Washington street, junction Dedham street	16
Washington street, junction Newton street	21
Washington street, junction Northampton street	32
Washington street, junction Waltham street	27
West Chester park, junction Belvedere street	20
West Chester park, junction Westland avenue	26

SOUTH BOSTON.

A street, junction Congress street	10
Dorchester avenue, junction Broadway	25
Dorchester avenue, junction Dorchester street	17
Dorchester avenue, junction East First street	16
Dorchester avenue, junction Kemp street	11
Dorchester avenue, junction Middle street	17
Dorchester avenue, junction West Seventh street	18
Dorchester street, junction Broadway	20
Dorchester street, junction Eighth street	20
Dorchester street, junction East Second street	18
Dorchester street, junction Newman street	15
Dorchester street, junction Old Harbor street	16
Dorchester street, junction Woodward street	15
Dorr street, junction Earl street	9
East Broadway junction I street	17
East Broadway, junction M street	12
East Broadway, junction O street	9
East Eighth street, junction G street	12
East Eighth street, junction Mercer street	18
East Fifth street, junction N street	12
East First street, junction I street	16
East First street, junction L street	12
East First street, junction O street	12
East Fourth street, junction L street	14
East Fourth street, junction P street	12

East Ninth street, junction K street	12
East Ninth street, junction Old Harbor street	12
East Second street, junction P street	12
East Seventh street, junction I street	15
East Seventh street, junction N street	12
East Sixth street, junction G street	5
East Sixth street, junction H street	12
East Sixth street, junction L street	14
East Sixth street, junction P street	12
East Third street, junction I street	16
East Third street, junction K street	12
East Third street, junction O street	9
Foundry street, junction West Fourth street	18
Foundry street, junction Ontario street	15
Granite street, junction Mt. Washington avenue	14
Granite street, junction Richards street	20
Newman street, junction Lowland street	6
Old Harbor street, junction Telegraph street	3
Pacific street, junction Thomas park	8
Ward street, junction Preble street	9
West Broadway, junction B street	18
West Broadway, junction F street	17
West Fifth street, junction B street	18
West Fifth street, junction F street	14
West First street, junction B street	14
West First street, junction D street	18
West First street, junction F street	14
West First street, junction Granite street	25
West Fourth street, junction A street	20
West Fourth street, junction D street	22
West Ninth street, junction D street	17
West Ninth street, junction Lark street	15
West Seventh street, junction D street	20
West Seventh street, junction F street	20
West Third street, junction A street	25
West Third street, junction C street	14
West Third street, junction E street	16

EAST BOSTON.

Bennington street, junction Chelsea street	14
Bennington street, junction Marion street	14
Bennington street, junction Putnam street	15
Brooks street, junction Condor street	8
Central square	21
Chelsea street, junction Brooks street	16
Chelsea street, junction Curtis street	4

Chelsea street, junction Decatur street . . .	10
Chelsea street, junction Eagle street . . .	10
Chelsea street, junction Marion street . . .	12
Chelsea street, junction Porter street . . .	10
Condor street, junction Putnam street . . .	12
Eagle street, junction Falcon street . . .	17
Marginal street, junction Cottage street . . .	13
Marginal street, junction Lewis street . . .	14
Marginal street, junction Orleans street . . .	14
Marginal street, junction R. B. & L. R.R. . . .	8
Maverick street, junction Border street . . .	16
Maverick street, junction Cottage street . . .	12
Maverick street, junction Lamson street . . .	8
Maverick street, junction London street . . .	16
Meridian street, junction Condor street . . .	12
Meridian street, junction London street . . .	20
Meridian street, junction Maverick street . . .	16
Meridian street, junction Princeton street . . .	21
Meridian street, junction Trenton street . . .	18
Meridian street, junction White street . . .	17
Moore street, junction Homer street . . .	4
Porter street, junction Havre street . . .	12
Princeton street, junction Brooks street . . .	10
Princeton street, junction Marion street . . .	10
Princeton street, junction Prescott street . . .	12
Princeton street, junction Putnam street . . .	12
Saratoga street, junction Moore street . . .	6
Saratoga street, junction Swift street . . .	8
Sumner street, junction Cottage street . . .	13
Sumner street, junction Jeffries street . . .	8
Sumner street, junction Lamson street . . .	8
Sumner street, junction Lewis street . . .	16
Sumner street, junction Liverpool street . . .	16
Sumner street, junction Orleans street . . .	15
White street, junction Brooks street . . .	12
White street, junction Putnam street . . .	10

CHARLESTOWN.

Alford street, junction Arlington avenue . . .	8
Arlington avenue, junction Dorrance street . . .	6
Austin street, junction Lawrence street . . .	20
Bartlett street, junction Concord street . . .	18
Bartlett street, junction Cross street . . .	18
Bartlett street, junction Salem street . . .	17
Bartlett street, junction Walker street . . .	13
Bunker Hill street, junction Belmont street . . .	10

Bunker Hill street, junction Concord street . . .	18
Bunker Hill street, junction Pearl street . . .	20
Bunker Hill street, junction Quincy street . . .	17
Bunker Hill street, junction Tufts street . . .	18
Cambridge street, junction Parker street . . .	10
Cambridge street, junction Perkins street . . .	17
Chelsea street, junction Henley street . . .	20
Chelsea street, junction Prospect street . . .	16
Chelsea street, junction Vine street . . .	18
Front street, junction Arrow street . . .	20
High street, junction Concord street . . .	18
High street, junction Green street . . .	16
High street, junction Lexington street . . .	18
Main street, junction Auburn street . . .	20
Main street, junction Haverhill street . . .	17
Main street, junction Medford street . . .	23
Main street, junction Mill street . . .	20
Main street, junction Salem street . . .	20
Medford street, junction Baldwin street . . .	19
Medford street, junction Chelsea street . . .	20
Medford street, junction Lexington street . . .	20
Medford street, junction Mead street . . .	16
Medford street, junction Pearl street . . .	10
Perkins street, junction Brighton street . . .	15
Russell street, junction Mead street . . .	12
Rutherford avenue, junction Allen street . . .	12
Rutherford avenue, junction Dunstable street . . .	20
Rutherford avenue, junction Mill street . . .	12
Tremont street, junction Edgeworth street . . .	18
Tremont street, junction Lexington street . . .	20
Union street, junction Main street . . .	20
Union street, junction Washington street . . .	20
Warren street, junction Water street . . .	20
Water street, junction Joiner street . . .	20
Winthrop street, junction Main street . . .	20

ROXBURY.

Alaska street, junction Perrin street . . .	8
Albany street, junction Hunneman street . . .	18
Albany street, junction Mall street . . .	16
Blue Hill avenue, junction Cherry street . . .	10
Blue Hill avenue, junction Edgewood street . . .	8
Blue Hill avenue, junction Moreland street . . .	8
Blue Hill avenue, junction Quincy street . . .	6
Blue Hill avenue, junction Waverley street . . .	8
Brookline avenue, junction Burlington avenue . . .	8

Brookline avenue, junction Francis street . . .	12
Brookline avenue, junction Longwood avenue . . .	13
Brookline avenue, junction Maple avenue . . .	8
Cabot street, junction Windsor street . . .	16
Cedar street, junction Hawthorn street . . .	7
Centre street, junction Cedar street . . .	12
Centre street, junction Heath . . .	14
Centre street, junction Lamartine street . . .	10
Centre street, junction Pyncheon street . . .	12
Centre street, junction Sheridan avenue . . .	10
Centre street, junction Walden street . . .	10
Centre street, junction Wyman street . . .	7
Circuit street, junction Regent street . . .	8
Clifton street, junction Langdon street . . .	11
Dale street, junction Mills street . . .	8
Day street, junction Creighton street . . .	12
Dudley street, junction Adams street . . .	15
Dudley street, junction Dearborn street . . .	20
Dudley street, junction Dennis street . . .	15
Dudley street, junction Elmwood street . . .	22
Dudley street, junction Hampden street . . .	22
Dudley street, junction Highland street . . .	10
Elm Hill avenue, junction Cheney street . . .	6
Elm Hill avenue, junction Howland street . . .	10
Eustis street, junction Magazine street . . .	20
Hampden street, junction Norfolk avenue . . .	16
Heath street, junction Bickford street . . .	8
Heath street, junction Day street . . .	10
Highland street, junction Cedar street . . .	8
Highland street, junction Ellis street . . .	12
Highland street, junction Marcella street . . .	8
Highland street, junction Milmont street . . .	10
Humboldt avenue, junction Crawford street . . .	12
Humboldt avenue, junction Munroe street . . .	14
Huntington avenue, junction Longwood avenue . . .	17
Huntington avenue, junction Parker street . . .	13
Lambert avenue, junction Bartlett street . . .	6
Lambert avenue, junction Milmont street . . .	7
Moreland street, junction Fairland street . . .	8
Mt. Pleasant avenue, junction Fairland street . . .	4
Norfolk avenue, junction Gerard street . . .	18
Norfolk avenue, junction Magazine street . . .	18
Palmer street, junction Winslow street . . .	16
Parker street, junction Parker Hill avenue . . .	10
Parker street, junction Prentiss street . . .	16
Pyncheon street, junction Cedar street . . .	12
Pyncheon street, junction Heath street . . .	12

Regent street, junction Fountain street . . .	7
Roxbury street, junction Linden Park street . . .	6
Ruggles street, junction Duncan street . . .	13
Ruggles street, junction Parker street . . .	12
Ruggles street, junction Warwick street . . .	22
Ruggles street, junction Westminster street . . .	18
Shawmut avenue, junction Hammond street . . .	10
Shawmut avenue, junction Ruggles street . . .	20
Tremont street, junction Bumstead lane . . .	12
Tremont street, junction Heath street . . .	16
Tremont street, junction Francis street . . .	12
Tremont street, junction Parker street . . .	20
Tremont street, junction Prentiss street . . .	16
Tremont street, junction Pyncheon street . . .	26
Tremont street, junction Ruggles street . . .	20
Vernon street, junction Auburn street . . .	10
Vernon street, junction Haskins street . . .	10
Walden street, junction Minden street . . .	8
Walnut avenue, junction Bainbridge street . . .	12
Walnut avenue, junction Circuit street . . .	10
Walnut avenue, junction Dale street . . .	10
Walnut avenue, junction Townsend street . . .	14
Warren street, junction Clifford street . . .	12
Warren street, junction Dunreath street . . .	12
Warren street, junction Munroe street . . .	14
Warren street, junction Regent street . . .	10
Warren street, junction Warren place . . .	14
Warren street, junction Waumbuck street . . .	12
Washington street, junction Atherton street . . .	14
Washington street, junction Bartlett street . . .	8
Washington street, junction Circuit street . . .	10
Washington street, junction Dale street . . .	15
Washington street, junction Dudley street . . .	24
Washington street, junction Nawn street . . .	18
Washington street, junction Ruggles street . . .	24
Washington street, junction Thorndike street . . .	25
Washington street, junction Thornton street . . .	18
Washington street, junction Townsend street . . .	16
Washington street, junction Vernon street . . .	20
Washington street, junction Westminster avenue . . .	11
Westminster street, junction Windsor street . . .	9
Winthrop street, junction Cleveland street . . .	6

DORCHESTER.

Adams street, junction Ashmont street . . .	8
Adams street, junction King street . . .	7

Adams street, junction Minot street	6
Adams street, junction Neponset avenue	9
Adams street, junction Richmond street	5
Allston street, junction Centre street	2
Ashland street, junction Mill street	4
Ashland street, junction Park street	5
Ashmont street, junction Carruth street	3
Ashmont street, junction Train street	2
Bird street, junction Bodwell park	4
Boston street, junction Eastman street	14
Boston street, junction Mt. Vernon street	12
Bowdoin street, junction Adams street	4
Bowdoin street, junction Olney street	4
Bowdoin street, junction Washington street	5
Blue Hill avenue, junction Columbia street	8
Blue Hill avenue, junction Harvard street	5
Blue Hill avenue, junction Norfolk street	4
Blue Hill avenue, junction River street	4
Blue Hill avenue, junction Wales street	6
Carruth street, junction Beale street	2
Columbia street, junction Bird street	4
Columbia street, junction Seaver street	4
Columbia street, junction Quincy street	4
Columbia street, junction Stanwood street	5
Columbia street, junction Washington street	8
Commercial street, junction Greenwich street	11
Commercial street, junction Park street	9
Cottage street, junction Boston street	17
Cottage street, junction Clifton street	8
Cottage street, junction Norfolk avenue	12
Cottage street, junction Pleasant street	9
Crescent avenue, junction Carson street	4
Dorchester avenue, junction Adams street	12
Dorchester avenue, junction Ashmont street	8
Dorchester avenue, junction Beach street	5
Dorchester avenue, junction Codman street	5
Dorchester avenue, junction Commercial street	18
Dorchester avenue, junction Crescent avenue	13
Dorchester avenue, junction King street	7
Dorchester avenue, junction Leeds street	12
Dorchester avenue, junction Mayfield street	14
Dorchester avenue, junction Mt. Vernon street	10
Dorchester avenue, junction Parkman street	8
Dorchester avenue, junction Savin Hill avenue	16
Dorchester avenue, junction Washington street	5
Dudley street, junction Cottage street	18
Dudley street, junction Howard avenue	11

Dudley street, junction Magnolia street . . .	9
Dudley street, junction Monadnock street . . .	12
East Chester park, junction Clapp street . . .	2
Erie avenue, junction Michigan avenue . . .	4
Freeport street, junction Pleasant street . . .	3
Freeport street, junction Preston street . . .	7
Glen street, junction Trull street . . .	3
Hamilton avenue, junction Clark street . . .	4
Hancock street, junction Rill street . . .	4
Hartford street, junction Robinhood street . . .	5
Harvard street, junction Gleason street . . .	5
Harvard street, junction School street . . .	4
Harvard street, junction Wales street . . .	5
Howard avenue, junction Quincy street . . .	5
Howard avenue, junction Sargent street . . .	5
Lauriat avenue, junction Lyons street . . .	2
Magnolia street, junction Howard avenue . . .	5
Magnolia street, junction Robinhood street . . .	4
Milton avenue, junction Evans street . . .	3
Minot street, junction Sheridan street . . .	5
Neponset avenue, junction Commercial street . . .	6
Neponset avenue, junction Minot street . . .	6
Neponset avenue, junction Park street . . .	9
Neponset avenue, junction Pope's Hill street . . .	7
Neponset avenue, junction Taylor street . . .	3
Norfolk avenue, junction Marshfield street . . .	10
Norfolk street, junction Chipman street . . .	3
Norfolk street, junction Freemont street . . .	4
Norfolk street, junction Nelson street . . .	3
Ocean street, junction Welles avenue . . .	3
Pleasant street, junction Mayfield street . . .	10
Richfield street, junction Puritan avenue . . .	4
River street, junction Cedar street . . .	4
River street, junction Temple street . . .	5
Sanford street, junction Cedar street . . .	3
Sanford street, junction Temple street . . .	4
Savin Hill avenue, junction Grampian way . . .	4
Savin Hill avenue, junction Midland street . . .	8
Sawyer avenue, junction Cushing avenue . . .	2
Walnut street, junction Ericsson street . . .	4
Walnut street, junction Franklin street . . .	5
Washington street, junction Ashmont street . . .	4
Washington street, junction Centre street . . .	5
Washington street, junction Fuller street . . .	3
Washington street, junction Wheatland avenue . . .	5
Wheatland avenue, junction Whitfield street . . .	3

WEST ROXBURY.

Alveston street, junction Greenough street . . .	6
Alveston street, junction Revere street . . .	7
Anawan avenue, junction Beech street . . .	3
Anawan avenue, junction Park street . . .	6
Ashland street, junction Florence street . . .	5
Beech street, junction Sycamore street . . .	6
Bellevue street, junction Oriole street . . .	6
Bellevue street, junction Rutledge street . . .	3
Boylston street, junction Burr street . . .	5
Boylston avenue, junction Amory street . . .	6
Brookside avenue, junction Cornwall street . . .	4
Brown avenue, junction Ashland street . . .	4
Brown avenue, junction Poplar street . . .	4
Centre street, junction Boylston street . . .	9
Centre street, junction Burroughs street . . .	18
Centre street, junction Central avenue . . .	4
Centre street, junction Corey street . . .	5
Centre street, junction Eliot street . . .	21
Centre street, junction Green street . . .	18
Centre street, junction La Grange street . . .	3
Centre street, junction May street . . .	6
Centre street, junction Mt. Vernon street . . .	5
Centre street, junction Orchard street . . .	7
Centre street, junction Pond street . . .	9
Centre street, junction Spring Park street . . .	7
Centre street, junction Walter street . . .	3
Chestnut street, junction Fessenden street . . .	5
Corey street, junction Carl street . . .	5
Corey street, junction Weld street . . .	4
Eliot street, junction Brewer street . . .	14
Green street, junction Boylston avenue . . .	5
Green street, junction Chestnut avenue . . .	9
Green street, junction Lamartine street . . .	5
Grove street, junction Washington street . . .	2
Hyde Park avenue, junction Ashland street . . .	4
Hyde Park avenue, junction Neponset avenue . . .	4
Keyes street, junction Starr street . . .	4
Metropolitan avenue, junction Poplar street . . .	4
Pond street, junction Eliot street . . .	11
Pond street, junction May street . . .	8
Pond street, junction Prince street . . .	12
Poplar street, junction Sycamore street . . .	4
Prince street, junction Perkins street . . .	8
Rockview street, junction St. Johns street . . .	7
South street, junction Custer street . . .	11

South street, junction Keyes street	10
Spring Park avenue, junction Rockview street	7
Spring street, junction Baker street	2
Spring street, junction Clarence street	2
Walk Hill street, junction Canterbury street	5
Walk Hill street, junction Hyde Park avenue	6
Washington street, junction Albano street	2
Washington street, junction Ashland street	5
Washington street, junction Beach street	4
Washington street, junction Boylston street	6
Washington street, junction Cornwall street	5
Washington street, junction Metropolitan avenue	3
Washington street, junction School street	10
Weld street, junction Church street	3
Weld street, junction Willow street	4

BRIGHTON.

Allston street, junction Allston square	2
Bennett street, junction Parsons street	5
Brighton avenue, junction Cambridge street	5
Brighton avenue, junction Chester street	6
Brighton avenue, junction Harvard avenue	5
Brooks street, junction Faneuil street	4
Brooks street, junction Newton street	3
Cambridge street, at Charles river	3
Cambridge street, junction Gordon street	10
Cambridge street, junction Harvard avenue	5
Cambridge street, junction North Harvard street	4
Cambridge street, junction Sparhawk street	8
Cambridge street, junction Washington street	10
Chester street, junction Ashford street	5
Chestnut Hill avenue, junction South street	9
Chestnut Hill avenue, junction Union street	10
Englewood avenue, junction Isleworth street	9
Everett street, junction Lincoln street	4
Everett street, junction Western avenue	4
Faneuil street, junction Parsons street	2
Harvard avenue, junction Commonwealth avenue	5
Lake street, junction Kenwick street	6
Market street, junction North Beacon street	4
Market street, junction Sparhawk street	5
Market street, junction Western avenue	4
North Beacon street, at Albany R.R.	3
North Beacon street, junction Dustin street	4
North Harvard street, at Charles river	2
North Harvard street, junction Western avenue	4

Washington street, junction Allston street . . .	4
Washington street, junction Foster street . . .	10
Washington street, junction Lake street . . .	8
Washington street, junction Market street . . .	10
Washington street, near Newton line . . .	2
Washington street, junction Shannon street . . .	8
Washington street, junction Tremont street . . .	5
Washington street, junction Union street . . .	6

IN GENERAL.

A contract was made with Donovan & Brock on August 22 for building the masonry foundations for Engine No. 3 at Chestnut-hill Pumping-station, and the work is nearly completed.

A contract was made with N. F. Palmer, Jr., & Co., of New York, on June 8, for building and erecting Pumping-engine No. 3, in accordance with plans made by Mr. E. D. Leavitt.

The engine will be triple expansion, working three double-acting pumps, with the Riedler patent valve gear, capable at fifty revolutions of pumping 20,000,000 gallons in twenty-four hours, and maintaining a duty of 140,000,000 ft. lbs. per 100 lbs. of coal.

Plans have also been made by Mr. Leavitt for a 90-inch Belpaire boiler, to supply steam at 185 lbs. pressure for the engine.

The rebuilding of the Brookline-avenue bridge over Muddy river, required the shutting off of the 40-inch main for several months, and the head throughout the low service was materially reduced. The pipe is relaid in the form of a siphon over the arch of the bridge.

The 30 and 36-inch mains must be relaid over the new bridge on Tremont street at the Brookline line. New 36-inch valves were placed in the 36 and 40-inch mains near the corner of Francis street. Five bents of piles, with 10 × 10 hard-pine caps, were placed under the 40-inch main in Beacon street, near Exeter street, to replace the old trusses which supported the pipe over the former sluices of the Water Power Company.

A plan of a storage reservoir of a capacity of one million gallons, for Long Island, has been made for the Directors of Public Institutions. This reservoir will cause a more constant circulation on the pipe line to the island, and the danger of freezing the pipe will be lessened.

Forty contracts for rock excavation were made during the year. Two hundred and ninety-five petitions for main pipe

extensions were reported upon in regard to grade of street, size of pipe, and cost of laying.

The pipe laid has been measured, the gates and hydrants have been located and plotted on the plans.

Thirty-three profiles of unaccepted streets have been made and grades given for grading the streets and laying pipes where required.

The records from the four pumping-stations, the lakes, reservoirs, the Mystic sewer, and the returns from pipe foundries, etc., have been carefully kept.

Appended to this report will be found the usual tables of rainfall, consumption, yield of water-sheds, etc.

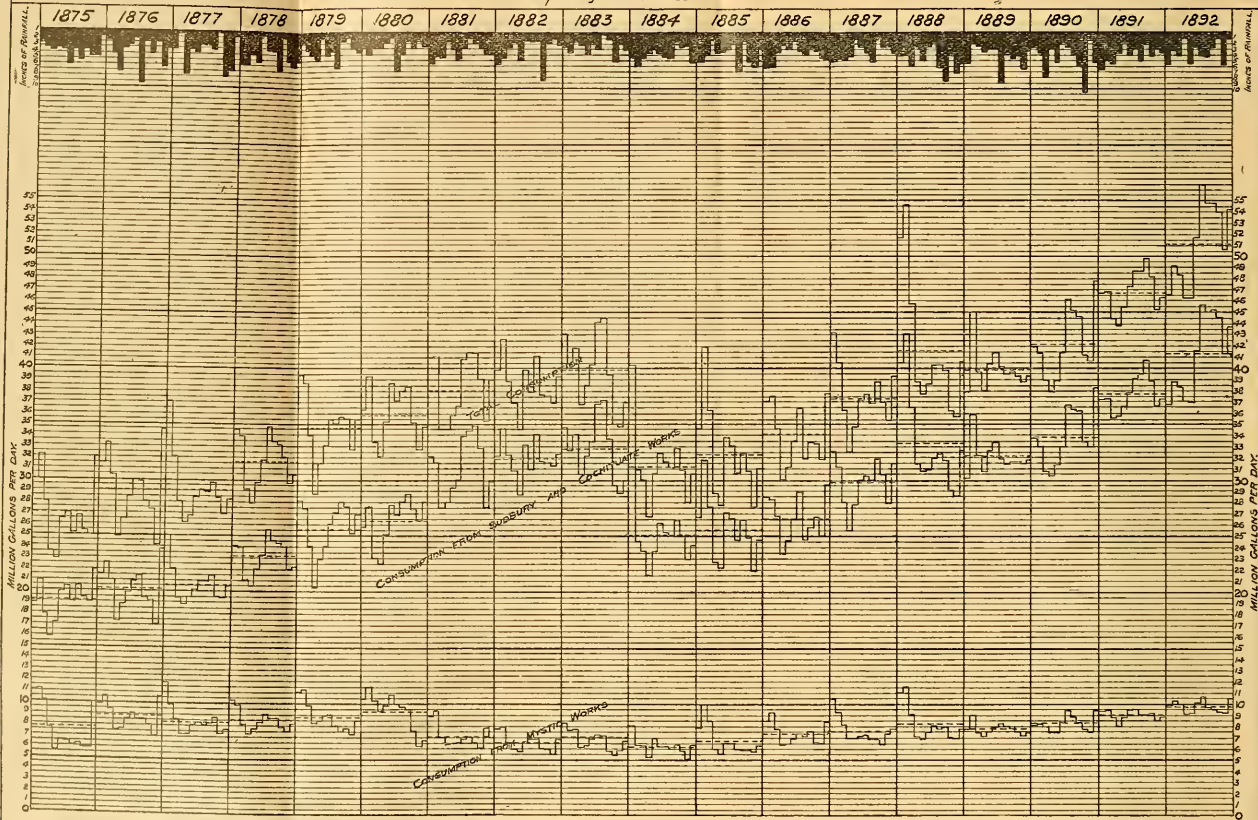
Respectfully submitted,

WILLIAM JACKSON,
City Engineer.

BOSTON WATER WORKS.

Diagram showing the rainfall and daily average Consumption for each month.

Yearly Averages shown thus-----



Daily Average Consumption of Water, in Gallons, from the Cochituate and Mystic Works.

COCHITUATE WORKS.												MYSTIC WORKS.											
MONTH.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1886.	1887.	1888.	1889.	1890.	1891.	1892.									
January	28,561,900	32,687,600	40,485,700	30,172,000	33,680,000	37,230,100	36,756,400	8,510,300	10,488,600	11,107,100	7,760,500	8,187,900	9,389,300	9,878,200									
February	28,291,100	31,224,300	43,105,000	35,855,200	33,030,700	37,280,700	38,881,500	9,275,700	9,346,700	11,620,900	9,073,600	8,299,700	9,466,900	10,332,200									
March	26,886,800	28,124,100	36,463,400	32,180,000	30,844,400	35,533,400	38,395,100	7,780,000	8,175,000	9,242,000	7,537,600	8,055,800	8,811,000	9,970,500									
April	23,470,400	25,591,500	31,473,800	30,814,500	30,446,600	35,751,600	37,171,000	6,636,500	6,633,800	7,276,700	7,185,700	7,481,600	8,045,800	9,145,000									
May	24,680,100	27,925,000	30,802,000	32,719,500	31,381,200	36,580,700	37,055,900	6,444,000	6,916,300	6,932,300	7,663,600	7,488,400	8,841,300	9,204,900									
June	26,574,900	30,069,000	31,026,100	33,377,900	33,022,700	37,801,900	41,564,000	6,941,100	7,159,800	7,615,200	8,017,700	8,396,000	9,478,400	10,146,300									
July	28,087,500	30,469,700	32,014,400	31,870,300	36,701,100	39,062,600	45,738,100	7,437,500	7,250,000	8,267,500	8,315,600	9,463,300	9,581,700	10,702,900									
August	24,770,600	30,063,100	32,432,700	31,403,200	36,316,900	39,490,400	45,031,600	7,166,800	6,871,900	7,850,100	8,113,200	8,932,200	9,122,300	9,751,500									
September . . .	25,835,600	31,946,600	31,836,500	31,722,800	36,105,800	40,677,700	45,261,900	7,555,200	6,868,600	7,266,300	7,966,000	8,436,700	9,128,700	9,549,400									
October	26,713,100	30,562,700	29,110,800	31,702,200	33,429,800	38,845,600	44,626,700	6,552,000	6,436,600	7,096,400	7,627,500	7,784,100	9,259,100	9,340,500									
November . . .	25,036,200	28,062,000	28,590,900	31,532,400	32,955,100	36,640,800	41,347,800	6,546,000	7,361,200	6,990,800	7,316,700	7,601,300	8,585,200	9,230,000									
December	29,706,800	31,511,500	32,686,200	31,829,000	38,334,100	37,342,500	43,766,400	8,043,500	7,835,300	7,918,600	7,473,200	9,448,300	8,960,600	10,473,700									
Yearly average .	26,627,900	29,552,100	33,310,700	32,070,000	33,871,700	37,686,900	41,312,400	7,399,800	7,629,000	8,258,400	7,830,500	8,301,400	9,055,200	9,810,800									

Division of Sudbury-River Water, 1884-1892.

MONTH.	1884.		1885.	1886.	1887.	1888.	1889.		1890.	1891.	1892.	
	To Lake Cochituate.	To Chestnut- Hill Res'r.	To Chestnut- Hill Res'r.	To Chestnut- Hill Res'r.	To Chestnut- Hill Res'r.	To Chestnut- Hill Res'r.	To Lake Cochituate.	To Chestnut- Hill Res'r.	To Chestnut- Hill Res'r.	To Chestnut- Hill Res'r.	To Lake Cochituate.	To Chestnut- Hill Res'r.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
January	697,000,000	473,900,000	502,200,000	602,200,000	895,400,000	484,500,000	715,900,000	518,600,000	630,800,000			
February	1,094,300,000	265,400,000	380,800,000	472,000,000	906,700,000	564,600,000	560,800,000	475,000,000	610,400,000			
March	312,500,000	495,900,000	467,400,000	456,700,000	691,400,000	584,500,000	573,200,000	498,600,000	625,200,000			
April	228,800,000	350,400,000	307,000,000	385,400,000	468,800,000	490,500,000	641,900,000	417,000,000	662,500,000			
May	268,400,000	308,500,000	344,700,000	444,200,000	566,300,000	615,700,000	740,300,000	536,300,000	690,400,000			
June	168,400,000	414,500,000	427,100,000	463,600,000	489,000,000	567,600,000	629,500,000	513,100,000	779,300,000			
July	152,000,000	430,100,000	534,500,000	387,500,000	528,900,000	524,000,000	755,100,000	864,100,000	948,000,000			
August	1,600,000	406,100,000	463,100,000	352,800,000	626,600,000	443,700,000	722,900,000	625,500,000	897,700,000			
September	442,200,000	386,100,000	414,700,000	577,300,000	581,600,000	475,500,000	732,400,000	606,400,000	876,300,000			
October	432,900,000	368,300,000	474,100,000	672,300,000	435,900,000	414,100,000	539,900,000	539,900,000	908,500,000			
November	363,900,000	297,600,000	381,800,000	607,100,000	410,900,000	454,600,000	752,200,000	526,000,000	788,000,000			
December	432,500,000	379,900,000	570,200,000	708,000,000	605,200,000	501,200,000	767,100,000	675,500,000	1,216,100,000			
Totals	1,416,300,000	4,694,300,000	5,224,700,000	6,124,100,000	7,224,700,000	223,400,000	6,130,500,000	6,596,000,000	9,633,200,000			
Total diversion from Sud- bury river	6,110,600,000	5,224,700,000	5,267,600,000	6,124,100,000	7,224,700,000	6,363,900,000	8,306,600,000	10,535,500,000				
Average daily diversion for whole year	16,695,600	14,311,200	14,431,800	16,778,400	19,739,600	17,435,300	22,757,800	18,071,200	28,800,000			

Statement showing Amount of Water diverted from Sudbury River to Lake Cochituate and Chestnut-Hill Reservoir; Amount wasted; Amount of Flow in River; Percentage of Rainfall collected, etc., 1875 to 1892.

(Water shed from 1875 to 1878, inclusive, = 77,764 sq. miles; in 1879 and 1880 = 78,238 sq. miles; and from 1881 to 1892, inclusive, = 75.2 sq. miles.)

YEAR.	Amount of Water diverted to Lake Cochituate and Chestnut-Hill Reservoir.	Amount of Water used by Framingham Water Co.	Amount of Water wasted from River.	STORAGE.		Total amount of flow in River.	Daily average amount of flow in River.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
				Gain.	Loss.					
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Inches.	Inches.	Per cent.
1875	2,555,800,000		24,971,600,000	66,300,000		27,593,700,000	75,599,200	45.490	20.418	44.88
1876	2,528,300,000		23,942,300,000		160,700,000	32,300,000,000	88,278,400	49.563	23.908	48.24
1877	1,894,350,000		32,438,300,000	112,100,000		34,444,750,000	94,369,200	44.018	25.487	57.90
1878	3,422,100,000		37,125,200,000	654,700,000		41,202,000,000	112,882,200	57.331	30.487	52.63
1879	3,749,200,000		20,817,500,000	962,200,000		25,528,900,000	69,942,200	41.419	18.775	45.33
1880	6,230,200,000		11,290,000,000		958,600,000	16,561,600,000	42,250,300	38.177	12.182	31.91
1881	8,845,300,000		17,279,000,000	751,700,000		26,576,000,000	73,633,900	44.169	20.565	46.56
1882	7,735,200,000		16,273,900,000		352,600,000	23,656,600,000	64,812,300	39.394	18.102	45.95
1883	8,455,000,000		7,251,900,000		1,086,400,000	14,620,500,000	40,056,200	32.780	11.188	34.13
1884	6,110,600,000		23,225,900,000	1,744,600,000		31,084,100,000	84,929,200	47.135	23.784	50.46
1885	5,224,700,000	61,800,000	19,878,800,000		446,300,000	24,718,400,000	67,721,600	43.545	18.916	43.44
1886	5,266,600,000	76,600,000	23,023,000,000	1,464,500,000		29,831,700,000	81,730,700	46.065	22.825	49.55
1887	6,124,100,000	87,500,000	25,334,500,000	117,400,000		31,063,500,000	86,749,300	42.705	24.227	56.73
1888	7,224,700,000	61,500,000	39,040,500,000	390,600,000		46,717,300,000	127,642,900	57.465	33.749	62.21
1889	6,363,900,000	59,500,000	31,550,400,000		2,800,000	37,971,000,000	104,030,100	49.95	29.056	58.17
1890	6,506,000,000	74,500,000	28,667,100,000		57,400,000	35,280,200,000	96,658,100	53.00	26.998	50.94
1891	8,306,600,000	80,500,000	28,799,600,000		1,100,800,000	36,085,900,000	98,865,500	49.52	27.612	55.76
1892	10,535,500,000	82,800,000	11,143,000,000		257,700,000	21,803,600,000	58,753,000	41.83	16.456	39.34
Averages .	5,953,841,700	73,100,000	23,780,700,000			29,869,263,900	81,605,400	45.786	22.596	48.56

Statement showing Amount of Water drawn from Lake Cochituate; Amount wasted; Amount of Rainfall collected in Lake; Amount received into Lake from Sudbury River; Percentage of Rainfall collected, etc., 1852 to 1892; Water-shed of Lake, 12,077 Acres.

YEAR.	Amount of Water drawn from Lake.	Amount of Water wasted from Lake.	Amount received into Lake from Sudbury River.	STORAGE.		Total amount of Rainfall collected in Lake.	Daily average amount of Rainfall collected in Lake.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
				Gain.	Loss.					
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Inches.	Inches.	Per cent.
1852 ¹	2,974,042,800	4,020,566,900	..	..	261,360,000	6,733,249,700	18,396,900	47.93	20.61	43.
1853	3,117,933,500	3,166,417,500	..	239,580,900	..	6,523,937,000	17,873,800	55.73	19.51	35.
1854	3,614,230,000	4,137,733,000	..	..	217,800,000	7,584,163,000	20,778,500	43.15	22.87	53.
1855	3,776,399,500	No account kept	..	..	326,700,000	..	..	34.96	..	..
1856	4,409,787,600	"	..	598,950,000	..	..	..	40.80	..	..
1857	4,644,990,000	10,625,900,000	..	32,670,000	..	15,303,560,000	41,927,600	63.10	46.69	74.
1858	4,639,155,000	1,934,500,000	..	..	141,570,000	6,482,085,000	17,759,000	48.66	19.46	40.
1859 ²	4,808,875,000	7,569,000,000	..	283,140,000	..	12,661,015,000	34,687,700	49.02	38.24	78.
1860	6,309,108,000	None.	..	174,240,000	..	6,483,348,000	17,714,100	55.44	19.40	35.
1861	6,639,035,900	3,377,559,000	..	..	1,459,200,000	8,557,394,900	23,444,900	45.44	25.45	56.
1862	6,059,000,000	33,290,000	..	1,306,800,000	..	7,399,000,000	20,271,200	49.69	22.36	45.
1863	5,927,052,500	2,165,696,500	..	762,300,000	..	8,855,049,000	24,260,400	69.30	26.88	39.
1864	6,105,306,700	1,368,746,000	..	..	1,848,577,000	5,625,475,700	15,370,200	42.60	18.35	43.
1865	4,621,630,000	1,688,120,700	..	743,242,500	..	7,052,993,200	19,323,300	49.46	20.50	41.
1866	4,463,585,000	None.	..	743,242,500	..	5,205,827,500	14,265,300	62.32	16.01	26.
1867	4,851,225,000	2,482,041,000	..	..	698,811,000	6,734,455,000	18,450,600	56.25	21.80	39.
1868	5,405,515,000	2,507,684,000	..	346,371,000	..	8,259,570,000	22,567,200	49.71	24.98	40.
1869	5,503,751,000	1,635,570,000	..	480,882,000	..	7,620,203,000	20,877,300	64.34	21.99	34.
1870	5,477,810,000	4,318,971,000	..	..	1,736,085,000	8,560,695,000	23,453,900	55.89	26.08	47.

1871	5,223,500,000	None.	.....	.....	.....	.....	250,033,000	4,972,567,000	13,623,500	45.39	15.16	33.
1872	5,775,151,200	None.	.....	.....	.....	.....	.....	5,642,480,300	15,416,600	48.47	17.22	35.
1873	6,511,826,900	2,917,977,000	.....	.....	.....	.....	515,132,000	8,914,671,900	24,423,800	45.43	27.13	60.
1874	6,623,972,900	1,145,851,700	.....	.....	.....	.....	1,367,715,000	6,402,109,600	17,540,000	35.93	19.52	54.
1875	7,092,955,500	None.	.....	.....	.....	.....	.....	5,760,040,300	15,780,900	45.49	17.57	39.
1876	7,277,175,200	1,619,243,800	.....	.....	.....	.....	.....	6,411,557,000	17,517,900	48.49	19.54	40.
1877	7,626,889,200	1,484,978,600	.....	.....	.....	.....	.....	7,596,244,800	20,811,600	43.80	23.17	53.
1878	7,743,904,700	3,341,875,000	.....	.....	.....	.....	.....	8,637,268,700	23,663,700	53.58	26.34	49.
1879	6,051,838,900	1,523,361,400	.....	.....	.....	.....	1,322,697,300	5,841,203,000	16,003,300	38.01	17.81	47.
1880	4,284,147,100	65,577,700	.....	.....	.....	.....	146,265,000	3,376,759,800	9,226,100	35.83	10.30	23.
1881	2,846,459,700	2,231,016,700	.....	.....	.....	.....	.....	5,357,965,800	14,679,400	41.09	16.34	40.
1882	3,935,490,600	1,358,543,700	.....	.....	.....	.....	357,334,700	4,936,039,000	13,525,200	40.29	15.05	37.
1883	4,731,227,700	162,361,800	.....	.....	.....	.....	334,400,000	3,314,089,500	9,079,700	31.20	10.11	32.
1884	4,533,156,450	1,842,837,100	.....	.....	.....	.....	.....	6,300,130,250	17,213,450	45.57	19.21	42.
1885	4,091,674,900	1,006,622,800	.....	.....	.....	.....	.....	5,106,892,500	13,991,500	43.66	15.57	36.
1886	4,432,533,100	3,116,283,200	.....	.....	.....	.....	360,662,000	7,188,157,300	19,093,600	46.97	21.92	47.
1887	4,802,120,700	3,658,652,900	.....	.....	.....	.....	763,205,000	7,697,568,000	21,089,200	41.58	23.47	56.
1888	4,903,503,100	4,229,200,000	.....	.....	.....	.....	.....	10,157,012,100	27,751,400	56.93	30.97	54.
1889	5,570,423,600	3,375,923,000	.....	.....	.....	.....	.....	9,165,719,400	25,111,600	50.23	27.95	56.
1890	5,722,170,800	2,380,441,200	.....	.....	.....	.....	64,166,300	8,038,445,700	22,023,100	51.23	24.51	48.
1891	5,508,178,900	6,064,000,000	.....	.....	.....	.....	1,056,057,800	10,516,121,100	28,811,300	46.42	32.07	69.
1892	5,464,791,300	281,000,000	.....	.....	.....	.....	.....	5,033,775,600	13,753,500	39.04	15.35	39.
Averages	5,227,234,000	2,394,493,000	.....	.....	.....	.....	.....	7,231,039,700	19,798,800	47.77	21.99	45.5

¹ Observations of rainfall at Lake Cochituate commenced 1852, and these observations are assumed as correct for the whole district.

² Lake raised two feet.

Statement showing Amount of Water drawn from Mystic Lake; Amount wasted; Amount of Rainfall collected in Lake; Percentage of Rainfall collected, etc., 1876 to 1892; Water-shed of Lake, 17,200 Acres.

YEAR.	Amount of Water drawn from Lake.	Amount of Water wasted from Lake.	STORAGE.		Total amount of Rainfall collected in Lake.	Daily average amount of Rainfall col- lected in Lake.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
	Gallons.	Gallons.	Gain.	Loss.	Gallons.	Gallons.	Inches.	Inches.	Per cent.
1876	3,230,101,300	6,389,774,700		32,583,000	9,567,293,000	26,140,100	47.00	20.49	43.6
1877	3,069,554,800	7,250,223,560		16,291,400	10,303,486,900	28,228,700	43.095	22.06	51.2
1878	3,367,490,400	8,718,547,600		26,000,000	12,060,038,000	33,041,200	54.065	25.82	47.8
1879	3,400,848,200	4,625,691,800		203,000,000	7,913,540,000	21,680,900	35.30	16.94	48.0
1880	3,692,195,700	2,158,761,200		118,500,000	5,703,756,900	15,684,000	34.42	12.21	35.5
1881	2,815,579,900	5,534,300,000	371,200,000		8,721,079,900	23,893,400	41.91	18.67	44.5
1882	2,570,896,700	4,444,668,000	15,000,000		7,030,564,700	19,261,800	39.165	15.05	38.4
1883	2,664,514,200	2,034,702,000		347,579,000	4,351,637,800	11,922,300	31.22	9.32	29.84
1884	2,469,761,000	6,574,003,800	380,600,000		9,424,364,800	25,719,600	44.39	20.18	45.46
1885	2,639,278,800	5,558,860,500		33,200,000	8,194,939,300	22,451,900	44.50	17.55	39.43
1886	2,862,947,500	7,743,258,900		28,400,000	10,577,806,400	23,980,300	45.56	22.65	49.71
1887	2,954,257,500	7,414,213,000		11,000,000	10,357,470,500	28,376,600	46.42	22.17	47.77
1888	3,205,121,100	11,334,503,100		6,000,000	14,533,714,200	39,709,600	56.745	31.12	54.84
1889	3,007,539,800	8,879,787,500	12,000,000		11,899,327,300	32,600,900	50.395	25.48	50.56
1890	3,212,284,500	8,953,727,900		3,000,000	12,163,012,400	33,323,300	49.37	26.04	52.75
1891	3,500,817,500	10,027,714,400		171,000,000	13,257,531,900	36,600,000	47.40	28.60	60.34
1892	3,811,766,200	3,474,213,200	177,000,000		7,462,979,400	20,390,700	39.115	15.98	40.85
Average	3,092,056,200	6,536,884,600			9,624,855,500	26,348,900	44.122	20.61	45.91

STON WATER WORKS

Showing the amount of water used in the year 1892.
 The total amount of water used in the year 1892.



BOSTON WATER WORKS.

Diagram showing the heights of Sudbury River Reservoirs, Farm Pond, and Cochituate and Mystic Lakes, and the Rainfall on the Sudbury River Water Shed during the year 1892.

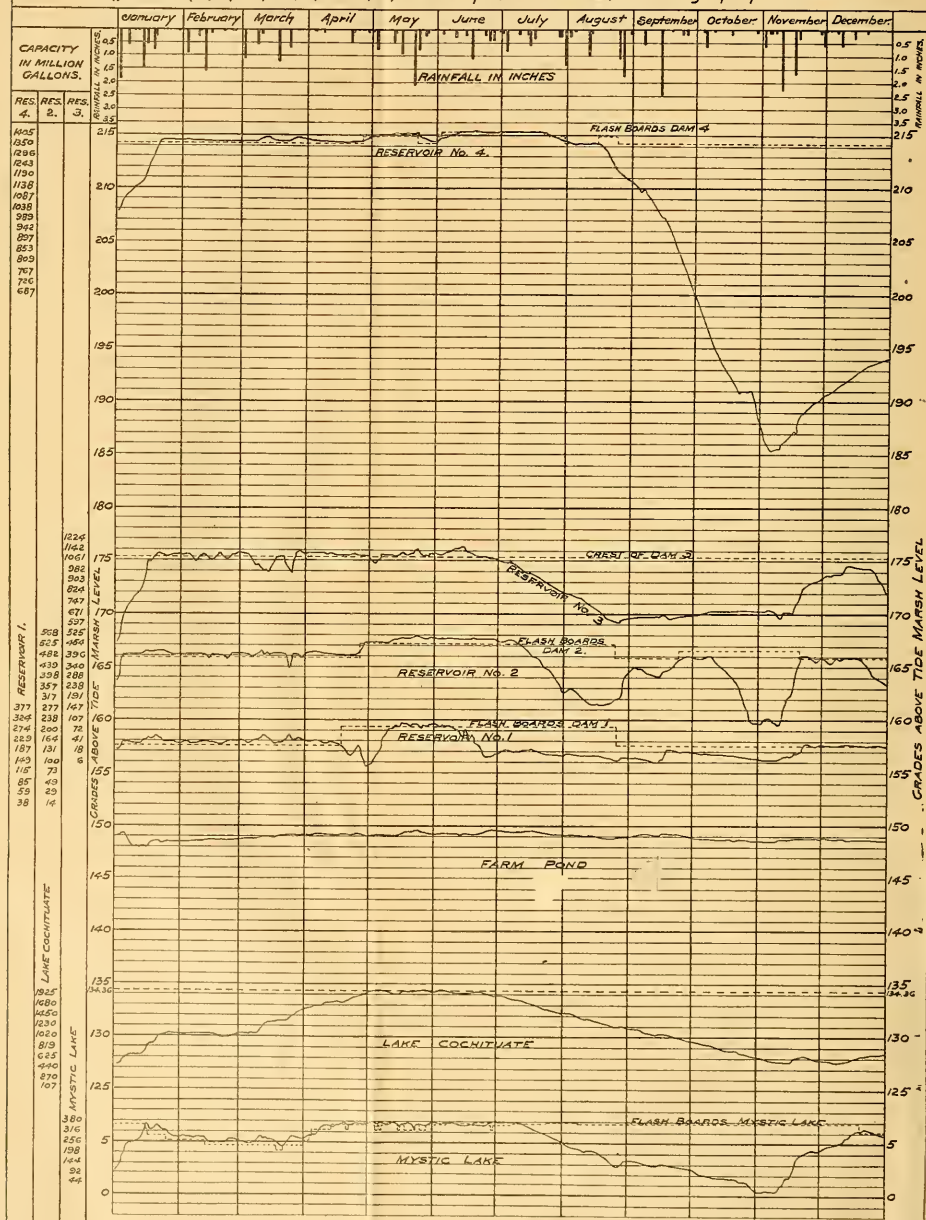


Table showing the Average Monthly and Yearly Heights above Tide-marsh Level of the Water in the Lakes and Reservoirs of the Boston Water-works.

MONTHS.	Reservoir No. 1. Flash boards. 159.29.	Reservoir No. 2. Flash boards. 167.12.	Reservoir No. 3. Stone crest. 175.24.	Reservoir No. 4. Flash boards. 215.21.	Farm Pond, High water, 149.25.	Lake Cochituate, High water, 134.36.	Chestnut- Hill Reservoir, High water, 124.00.	Brookline High water, 124.00.	Parker-Hill Reservoir, High water, 219.00.	Mystic Lake, High water, 7.00.	Mystic Reservoir, High water, 147.00.	Fisher-Hill Reservoir, High water, 241.00.												
	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.	1891. 1892.												
January .	158.23	157.91	166.20	166.02	175.32	173.17	213.85	211.91	149.48	148.49	132.95	129.03	123.48	123.49	123.25	123.26	218.78	218.64	4.75	5.26	146.96	146.95	240.12	240.57
February .	158.33	157.84	166.06	166.02	174.41	175.34	210.14	214.44	149.53	148.60	132.73	130.04	123.43	123.11	123.20	122.88	218.77	218.83	4.56	5.17	146.87	146.98	240.22	240.87
March . .	158.45	158.07	165.57	166.06	172.73	174.89	210.35	214.58	149.50	148.94	133.13	131.31	123.27	123.25	123.06	123.11	218.75	218.98	4.79	5.08	146.85	146.94	240.34	240.87
April . . .	158.15	157.35	166.12	166.26	175.50	175.50	214.25	214.48	149.33	149.09	134.23	133.39	123.52	123.47	123.32	123.35	218.76	218.95	5.81	6.41	146.63	146.72	240.17	240.77
May . . .	158.64	158.75	166.59	167.56	175.30	175.42	214.50	214.94	149.32	149.19	133.56	134.27	123.47	123.83	123.02	123.73	218.71	218.95	6.71	6.69	146.52	. .	240.00	240.69
June . . .	159.36	158.18	165.36	167.58	175.37	175.58	214.84	215.22	149.17	149.26	132.68	134.15	123.70	123.86	123.47	123.73	218.71	218.56	6.58	6.71	146.57	. .	240.10	240.81
July . . .	157.57	156.90	162.79	165.74	175.30	173.61	214.07	215.12	148.96	149.27	131.44	133.05	123.76	123.81	123.50	123.66	218.83	218.45	5.62	6.22	146.90	146.67	240.60	241.09
August . .	157.77	156.48	158.86	162.20	175.00	170.41	208.92	213.24	148.83	148.95	130.04	131.48	123.86	123.83	123.58	123.69	218.90	218.67	3.67	3.78	146.93	146.85	240.46	240.89
September,	157.88	156.57	160.47	164.97	173.17	169.74	204.72	206.41	148.94	149.04	129.02	130.17	123.69	123.76	123.43	123.44	218.67	218.39	2.29	2.77	146.84	146.85	240.35	240.84
October . .	157.44	156.60	158.51	163.74	169.84	170.05	202.35	193.34	148.81	148.73	127.67	128.79	123.69	123.88	123.43	123.62	218.69	218.69	0.20	1.47	146.56	146.86	240.61	241.09
November,	156.97	156.46	158.64	162.90	164.60	171.18	204.41	187.70	148.75	148.72	126.71	127.81	123.82	123.81	123.31	123.32	218.60	218.75	0.30	2.15	146.90	146.98	240.73	241.19
December .	157.00	157.55	162.15	165.14	164.03	173.82	206.51	192.61	148.84	148.71	126.72	127.93	123.73	123.52	123.51	123.19	218.91	217.88	0.68	5.52	146.84	146.93	240.62	240.99
Yearly averages }	157.98	157.39	163.11	165.35	172.34	173.23	209.99	207.83	149.12	148.92	130.91	130.95	123.62	123.63	123.34	123.41	218.76	218.64	3.78	4.77	146.78	146.87	240.36	240.89

Statement of Operations at the Chestnut-hill Pumping-station for 1892.

1892.	ENGINE No. 1.			ENGINE No. 2.			Total amount pumped.	Gallons.	Daily average amount pumped.	Pounds.	Daily average amount of coal consumed.	Total ashes and clinkers.	Per cent. ashes.	Quantity pumped per lb. of coal. No correction for heating and lighting.	Gallons.	Quantity pumped per lb. of coal. Corrected for heating and lighting.	Average lift in feet.	Duty in ft.-lbs. per 100 lbs. of coal.			Water evaporated in boiler per lb. of coal.
	ENGINE No. 1.		Total pump- ing time.	ENGINE No. 2.		Corrected for heating and lighting.												Corrected for heating and lighting.	Without correction for heating and lighting.		
	Total pump- ing time.	Amount pumped.		Total pump- ing time.	Amount pumped.																
Month.	Hrs.	Min.	Gallons.	Hrs.	Min.	Gallons.	Gallons.	Gallons.	Lbs.	Lbs.	Lbs.	Lbs.	Per cent.	Gallons.	Gallons.	Feet.	Feet.	Feet.	Feet.	Lbs.	Lbs.
Jan. . . .	624	00	243,190,625			243,190,625	7,844,900	289,944	9,353	25,703	8.9	838.8	960.4	125.69	87,922,400	92,142,700	100,159,100	10.12	11.95		
Feb. . . .			577	45		222,519,975	7,673,100	276,695	9,541	23,203	8.4	804.2	925.6	126.50	84,844,600	90,614,000	97,223,900	10.08	11.90		
March . .	612	10	239,939,875			239,939,875	7,741,600	290,103	9,358	26,058	9.0	827.3	934.0	126.48	87,262,700	92,236,700	98,139,800	10.05	11.88		
April . . .			615	25		237,857,025	7,928,600	285,308	9,510	25,297	8.9	833.7	912.9	126.44	87,912,900	89,583,200	96,122,800	10.26	12.09		
May . . .	628	15	245,655,350			245,655,350	7,924,400	276,009	8,904	23,783	8.6	890.0	965.6	125.87	93,431,100	94,365,400	101,348,500	10.45	12.22		
June . . .	23	30	9,916,425	621	40	245,150,605	8,502,200	283,760	9,450	23,455	8.3	898.9	942.9	126.07	94,510,700		99,141,700	10.20	11.81		
July . . .	693	40	232,466,925			232,466,925	9,111,800	304,265	9,815	26,749	8.8	928.4	972.0	126.46	97,911,800		102,513,700	10.33	11.92		
August . .			661	10		264,497,000	8,532,200	293,731	9,475	25,488	8.7	900.5	948.2	126.17	94,753,000		99,774,900	10.28	11.86		
Sept. . . .	654	45	265,588,500			265,588,500	8,853,000	293,226	9,774	24,274	8.3	905.7	961.9	126.29	95,398,000		101,313,300	10.31	11.94		
Oct. . . .	143	05	58,199,370	518	45	206,589,975	8,541,600	309,913	9,997	25,637	8.3	854.4	935.6	126.38	90,054,500	92,035,700	98,478,200	10.44	12.18		
Nov. . . .	537	25	224,856,375	63	45	24,175,250	8,301,100	293,605	9,954	24,740	8.3	834.0	942.4	126.07	87,687,000	91,194,500	98,763,000	10.31	12.12		
Dec. . . .			700	15		279,365,000	9,011,800	346,546	11,179	27,886	8.0	806.1	924.6	126.88	85,304,200	89,740,000	97,457,700	10.30	12.20		
Totals and averages,	3976	50	1,569,863,445	3758	45	1,480,154,830	8,333,400	3,543,105	9,694	302,323	8.5	850.6	943.8	126.27	90,525,800	92,879,500	99,193,300	10.26	12.01		

Statement of Operations at the Mystic Pumping-station for 1892.

1892.	ENGINE NO. 1.			ENGINE NO. 2.			ENGINE NO. 3.			Daily average amount of coal consumed.	Daily average amount pumped.	Gallons.	Lbs.	Daily amount of ashes and clinkers.	Per cent. ashes and clinkers.	Quantity pumped per pound of coal.	Average lift in feet.	Duty in foot-pounds of total coal.
	Total pumping-time.		Amount pumped.	Total pumping-time.		Amount pumped.	Total pumping-time.		Amount pumped.									
	Hrs.	Min.	Gallons.	Hrs.	Min.	Gallons.	Hrs.	Min.	Gallons.										Hrs.	Min.	Gallons.	Lbs.	Per ct.	Gals.	Feet.	Foot-pounds.
Month.																		
January	29	00	5,828,600	295	45	60,445,300	713	45	240,384,000	306,657,900	22,226	2,264	10.2	445.1	147.92	54,907,000		
February				329	15	63,314,300	696	00	236,262,400	299,576,700	22,241	2,406	10.8	464.5	147.83	57,263,400		
March				309	30	62,468,700	726	45	246,835,200	300,303,900	21,968	2,204	10.0	454.2	147.66	55,932,900		
April	367	30	70,094,200	444	30	91,566,400	342	30	111,948,800	273,609,400	21,612	2,101	9.7	421.9	147.34	51,845,100		
May				228	00	44,545,000	717	15	232,908,800	277,453,800	19,387	1,845	9.5	461.7	149.45	57,541,100		
June	62	45	12,533,000	386	00	84,137,200	696	15	234,368,000	331,038,200	24,367	2,315	9.5	452.9	151.29	57,139,600		
July	154	45	31,000,300	545	00	115,515,000	576	15	185,216,000	331,731,300	23,903	2,384	10.0	447.7	148.63	55,493,300		
August				295	45	58,346,400	730	15	243,891,200	302,237,600	21,032	2,184	10.4	463.6	149.65	57,855,400		
September				258	00	50,887,000	711	45	235,494,400	286,381,400	20,350	2,289	11.2	469.1	149.50	58,487,900		
October	55	15	11,566,600	258	45	51,022,900	686	15	226,395,200	289,584,700	20,274	2,130	10.5	460.8	149.46	57,433,000		
November				202	45	44,273,200	705	30	232,524,800	276,798,000	19,300	2,037	10.6	478.1	149.02	59,414,900		
December				344	30	72,676,300	739	45	239,667,200	312,343,500	21,500	2,234	10.4	468.6	148.40	58,000,600		
Totals and averages. }	669	15	131,022,700	3,897	45	799,198,200	8,042	15	2,666,495,500	3,596,716,400	21,511	2,198	10.2	456.8	148.84	56,709,900		

Rainfall in Inches and Hundredths, on the Sudbury River Water-shed for the Year 1892.

1892.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1					0.065		0.175					0.025
2	1.895		1.100					0.260			0.615	
3		0.880			0.770	0.175	0.795					0.010
4				0.070				0.050		0.125	0.070	
5										0.590	0.070	
6	0.620								0.055			0.100
7											0.065	
8		0.290	0.690	0.025								0.615
9	0.045	0.050				0.290	0.220			0.060		
10			0.330								2.275	
11	0.015	1.645			0.480			0.980				
12					0.100			0.140				
13	1.520						0.175					
14		0.160				0.225	0.605		2.440			0.280
15	0.600				0.900							
16							0.335				1.655	
17						1.110				0.285		
18	0.800		1.215								0.320	
19	0.320								0.045			
20		0.080										0.095
21				0.490	2.120							
22				0.125								
23			0.725		0.790	0.125						
24		0.030							0.150			
25		0.025				0.420		1.110				
26					0.235				0.150			
27					0.125	0.395		1.770				
28							0.275				0.140	
29				0.120			0.305			0.110		
30	0.035					0.020					0.590	
31							1.345	0.130				
Totals .	5.850	3.140	4.060	0.830	5.585	2.760	4.230	4.440	2.840	1.170	5.800	1.125

Total rainfall during the year, 41.830 inches, being an average of two gauges, located at Framingham and Ashland.

Rainfall in Inches and Hundredths at Lake Cochituate for the Year 1892.

1892.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	...	...	...	...	0.07	...	0.13	...	...	...	...	0.05
2	1.21	...	1.54	...	...	0.02	...	0.29	...	...	0.60	...
3	...	0.96	...	...	0.71	0.16	0.72	...	...	...	...	...
4	...	...	...	...	...	...	...	...	...	0.86	...	...
5	...	...	...	...	...	...	...	0.02	...	...	0.17	...
6	0.54	...	...	...	0.01	...	...	...	0.04	...	...	0.11
7	...	...	...	...	...	...	...	...	...	...	0.06	...
8	...	0.31	0.60	0.07	...	...	...	...	...	...	...	0.64
9	0.04	...	...	...	...	0.45	0.12	...	...	0.05	...	...
10	...	...	0.28	...	...	...	...	...	...	...	2.17	...
11	...	1.32	...	...	...	...	...	1.04	...	...	...	...
12	...	...	...	...	0.55	...	...	0.08	...	...	...	...
13	1.39	...	...	...	...	...	...	...	...	...	...	...
14	...	0.17	...	...	...	0.38	0.46	...	2.57	...	...	0.27
15	0.56	...	...	...	0.97	...	...	...	...	...	...	...
16	...	...	...	...	...	...	0.17	...	...	...	1.43	...
17	...	...	...	...	...	1.10	...	...	...	0.28	...	...
18	...	...	1.08	...	...	...	...	...	...	...	0.42	...
19	1.03	...	...	...	...	...	...	...	0.01	...	...	...
20	...	...	...	...	...	...	...	...	...	...	...	0.09
21	...	0.02	...	0.49	2.85	...	...	...	...	...	...	...
22	...	...	...	0.12	...	...	...	...	...	...	...	...
23	...	...	0.62	...	...	0.09	...	...	...	...	...	...
24	...	...	...	...	...	...	...	...	0.02	...	...	...
25	...	0.02	...	...	...	0.54	0.37	...	...	...	...	0.02
26	...	...	...	...	0.21	...	...	2.22	0.23	0.01	...	...
27	...	...	...	...	0.09	0.48	...	...	...	...	...	...
28	...	...	...	0.10	...	...	0.07	...	...	...	...	...
29	...	...	...	...	...	...	0.36	...	...	0.22	0.29	...
30	0.01	...	...	...	...	0.01	...	...	...	...	...	...
31	...	...	...	...	...	...	1.07	0.14	...	...	...	...
Totals .	4.78	2.80	4.12	0.78	5.46	3.23	3.47	3.79	2.87	1.42	5.14	1.18

Total rainfall during the year, 39.04 inches.

*Rainfall in Inches and Hundredths on the Mystic Water-shed for the year
1892.*

1892.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1					0.090		0.165	0.070			0.180	0.020
2	1.070		1.130									
3		1.010			0.695	0.205	0.770	0.525		0.030	0.405	
4				0.025		0.005		0.015		0.060		0.005
5								0.400	0.030	1.035	0.085	
6	0.580								0.035			0.110
7											0.030	
8		0.295	0.660	0.015								0.710
9	0.040					0.405	0.220	0.015		0.055		
10			0.380					0.010			1.870	0.020
11		1.535			0.560							
12					0.035			1.050				
13	1.425							0.150				
14		0.140				0.330	0.170		1.615			0.250
15	0.345		0.005		0.980							
16							0.160			0.410	1.295	
17						1.095						
18	0.875		1.125								0.260	
19	0.145								0.015			
20												0.035
21		0.005		0.515	2.255							
22				0.125								
23			0.705		0.630	0.070						
24	0.005											
25		0.030				1.025						
26					0.215			2.225	0.310	0.105		
27					0.120	1.010		0.090				
28				0.025			0.015				0.145	
29				0.110	0.005		0.175			0.140		
30	0.030					0.005					0.375	
31							0.900	0.270				
Totals .	4.515	3.015	4.005	0.815	5.585	4.150	2.575	4.820	2.005	1.835	4.645	1.150

Total rainfall during the year, 39.115 inches, being an average of two gauges, located at Mystic Lake and Winchester.

Monthly Rainfall in Inches, during 1892, at Various Places in Eastern Massachusetts.

PLACE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Framingham	6.00	3.20	4.01	0.85	5.57	2.75	4.22	4.48	2.59	1.28	5.81	1.14	41.90
Dam 4, Ashland	5.70	3.08	4.11	0.81	5.60	2.77	4.24	4.40	3.09	1.06	5.79	1.11	41.76
Lake Cochituate	4.78	2.80	4.12	0.78	5.46	3.23	3.47	3.79	2.87	1.42	5.14	1.18	39.04
Chestnut Hill	4.45	2.78	3.95	0.75	6.08	3.89	3.35	5.92	2.16	2.39	5.26	1.29	42.27
Mystic Lake	4.54	3.00	4.25	0.89	5.85	4.10	2.54	5.05	2.13	2.11	5.16	1.21	40.83
Mystic Station, Winchester	4.49	3.03	3.76	0.74	5.32	4.20	2.61	4.59	1.88	1.56	4.13	1.09	37.40
Mystic Pumping-station	4.50	2.60	4.06	0.92	5.64	3.87	3.53	4.88	1.88	1.94	4.82	1.26	38.90
Boston Pipe-yard	4.58	2.49	3.73	0.65	4.63	2.98	2.33	4.60	1.81	2.33	4.12	1.20	35.45
Cambridge Observatory	4.30	1.70	2.90	0.80	5.35	3.72	1.24	6.65	2.18	1.76	4.68	1.23	36.51
Waltham, Boston Manufacturing Co.	5.12	2.71	3.59	0.88	5.81	3.98	2.69	4.12	2.32	1.58	5.94	0.93	39.67
Lowell, Locks and Canals Co.	5.38	2.74	3.25	0.63	5.86	4.44	2.32	4.31	1.97	1.38	5.83	1.11	39.22
Average of eleven places	4.894	2.739	3.794	0.791	5.561	3.630	2.867	4.799	2.262	1.710	5.153	1.159	39.359

Rainfall Received and Collected, 1892.

MONTH.	SUDBURY.			COCHITUATE.			MYSTIC.		
	Rainfall.	Rainfall collected.	Per cent. collected.	Rainfall.	Rainfall collected.	Per cent. collected.	Rainfall.	Rainfall collected.	Per cent. collected.
	Inches.	Inches.	Per cent.	Inches.	Inches.	Per cent.	Inches.	Inches.	Per cent.
January . .	5.850	3.335	57.01	4.78	3.18	66.55	4.515	2.49	55.04
February . .	3.140	1.574	50.13	2.80	1.64	58.50	3.015	1.76	58.46
March . . .	4.060	3.488	85.90	4.12	3.12	75.67	4.005	3.03	75.72
April . . .	0.830	1.504	181.15	0.78	0.90	115.52	0.815	1.33	163.57
May	5.585	2.245	40.20	5.46	2.03	37.13	5.585	2.10	37.54
June	2.760	0.739	26.76	3.23	0.49	15.26	4.150	1.17	28.30
July	4.230	0.382	9.03	3.47	0.33	9.52	2.575	0.66	25.70
August . .	4.440	0.500	11.26	3.79	0.56	14.68	4.820	0.49	10.19
September .	2.840	0.396	13.94	2.87	0.60	21.10	2.005	0.56	27.71
October . .	1.170	0.224	19.18	1.42	0.57	40.16	1.835	0.45	24.29
November .	5.800	1.204	20.75	5.14	1.09	21.22	4.645	1.07	23.09
December .	1.125	0.865	76.89	1.18	0.84	71.09	1.150	0.87	75.23
Totals and averages, }	41.830	16.456	39.34	39.04	15.35	39.32	39.115	15.98	40.85

Table showing the Temperature of Air and Water at Various Stations on the Water-works.

1892.	TEMPERATURE OF AIR.						TEMPERATURE OF WATER.	
	Chestnut-Hill Reservoir.			Framingham.			Brookline Reservoir.	Mystic Engine-House.
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Mean.	Mean.
January	62.0	1.0	28.0	62.0	-3.0	25.7	36.5	36.3
February	44.5	3.5	27.6	49.0	-1.0	27.6	36.8	35.9
March	56.5	12.5	32.3	58.0	8.0	31.3	36.7	35.0
April	77.0	25.5	48.3	76.0	21.0	46.3	48.0	45.2
May	83.0	31.0	55.8	83.0	27.0	54.7	55.7	55.8
June	94.5	43.0	69.8	96.0	38.0	69.5	69.3	70.8
July	94.0	48.0	72.0	96.0	45.0	70.9	74.3	74.5
August	95.0	53.0	70.1	94.0	48.0	68.5	74.7	75.8
September	80.5	40.5	62.3	80.0	34.0	60.3	67.6	66.5
October	75.0	30.0	50.8	77.0	23.0	49.6	56.4	56.9
November	66.5	19.0	40.1	65.0	16.0	38.7	45.5	47.2
December	45.5	0.0	27.3	45.0	-2.0	26.6	36.6	36.8

SUMMARY OF STATISTICS.

REPORT FOR 1892.

Boston Water-Works, Suffolk County, Massachusetts, supplies also the cities of Somerville, Chelsea, and Everett.

Population by census of 1890 :

Boston	448,477
Chelsea	27,909
Somerville	40,152
Everett	11,068

Total	527,606
-----------------	---------

Date of construction :

Cochituate Works	1848
Mystic “	1864

By whom owned. — City of Boston.

Sources of supply. — Lake Cochituate, Sudbury river, and Mystic lake.

Mode of supply. — Sixty-five per cent. from gravity works.
 Thirty-five “ “ pumping “

PUMPING.

	COCHITUATE.	MYSTIC.
Builder of pumping machinery . . .	Holly Co.	H. R. Worthington.

Description of coal used :

<i>a</i> Kind . . .	Bituminous.	Bituminous.
<i>c</i> Size . . .	Broken.	Broken.
<i>e</i> Price per gross ton, in bins,	\$4.66	\$4.13
<i>f</i> Per cent. of ash,	8.5.	10.2.

	COCHITUATE.	MYSTIC.
Coal consumed for year, in lbs.	3,548,105	7,873,000
Total pumpage for year, in gallons	3,050,018,300	3,596,716,400
Average dynamic head, in feet	126.27	148.84
Gallons pumped per lb. of coal	943.8	456.8

	COCHITUATE.	MYSTIC.
Duty in foot-lbs. per 100 lbs. of coal	99,195,300	56,709,000
Cost of pumping figured on pumping-station expenses, viz :	\$18,761.07	\$25,512.19
Cost per million gallons raised to reservoir . . .	\$6.15	\$7.09
Cost per million gallons raised one foot high . .	\$0.049	\$0.048

CONSUMPTION.

Estimated population	433,600	124,800
Total consumption, gallons, 15,120,353,700		3,590,740,400
Passed through meters	4,108,687,500	681,577,500
Average daily consumption, gallons	41,312,400	9,810,800
Gallons per day, each in- habitant	95.3	78.6
Gallons per day to each tap, ...	635	454

DISTRIBUTION.

Mains.

	COCHITUATE.	MYSTIC.
Kind of pipe used, {	Cast-Iron.	Cast-Iron, Wrought- Iron and Cement.
Sizes	48-in. to 4-in.	30-in to 3-in.
Extended, miles	17.	2.4
Total now in use	536.	160.4
Distribution-pipes less than 4-in., length miles	0	5.5
Hydrants added	148	107
Hydrants now in use	5,834	1,223
Stop-gates added	219	110
Stop-gates now in use	5,910	1,799

Services.

	Lead.	Lead and Wrought-Iron.
Kind of pipe used, {	Lead.	Lead and Wrought-Iron.
Sizes	$\frac{5}{8}$ -in. to 6-in.	$\frac{1}{2}$ -in. to 4-in.
Extended, feet	59,807	31,584
Service-taps added	2,197	1,032
Total now in use	65,074	21,588
Meters added	73	29
Meters now in use	3,912	435
Motors and elevators in use	554	27

CIVIL ORGANIZATION OF THE WATER-WORKS, FROM THEIR COMMENCEMENT TO FEBRUARY 1, 1893.

WATER COMMISSIONERS.

NATHAN HALE,† JAMES F. BALDWIN,† THOMAS B. CURTIS. From May 4, 1846, to January 4, 1850.

ENGINEERS FOR CONSTRUCTION.

JOHN B. JERVIS, of New York, Consulting Engineer. From May, 1846, to November, 1848.†

E. S. CHESBROUGH, Chief Engineer of the Western Division. From May, 1846, to January 4, 1850.†

WILLIAM S. WHITWELL, Chief Engineer of the Eastern Division. From May, 1846, to January 4, 1850.

ENGINEERS HAVING CHARGE OF THE WORKS.

E. S. CHESBROUGH, Engineer. From November 18, 1850, to October 1, 1855.†

GEORGE H. BAILEY, Assistant Engineer. From January 27, 1851, to July 19, 1852.

H. S. McKEAN, Assistant Engineer. From July 19, 1852, to October 1, 1855.†

JAMES SLADE, Engineer. From October 1, 1855, to April 1, 1863.†

N. HENRY CRAFTS, Assistant Engineer. From October 1, 1855, to April 1, 1863.

N. HENRY CRAFTS, City Engineer. From April 1, 1863, to November 25, 1872.

THOMAS W. DAVIS, Assistant Engineer. From April 1, 1863, to December 8, 1866.

HENRY M. WIGHTMAN, Resident Engineer at C. H. Reservoir. From February 14, 1866, to November, 1870.†

A. FTELEY, Resident Engineer on construction of Sudbury-river works. From May 10, 1873, to April 7, 1880.

JOSEPH P. DAVIS, City Engineer. From Nov. 25, 1872, to March 20, 1880.

HENRY M. WIGHTMAN, City Engineer. From April 5, 1880, to April 3, 1885.†

WILLIAM JACKSON, City Engineer. From April 21, 1885, to present time.

DESMOND FITZGERALD, Resident Engineer on Additional Supply. From February 20, 1889, to present time.

After January 4, 1850, Messrs. E. S. CHESBROUGH, W. S. WHITWELL, and J. AVERY RICHARDS were elected a Water Board, subject to the direction of a Joint Standing Committee of the City Council, by an ordinance passed December 31, 1849, which was limited to keep in force one year; and in 1851 the Cochituate Water Board was established.

COCHITUATE WATER BOARD.

Presidents of the Board.

THOMAS WETMORE, elected in 1851, and resigned April

7, 1856† Five years.

JOHN H. WILKINS, elected in 1856, and resigned June 5, 1860†	Four years.
EBENEZER JOHNSON, elected in 1860, term expired April 3, 1865†	Five years.
OTIS NORCROSS, elected in 1865, and resigned January 15, 1867†	One year and nine months.
JOHN H. THORNDIKE, elected in 1867, term expired April 6, 1868†	One year and three months.
NATHANIEL J. BRADLEE, elected April 6, 1868, and resigned January 4, 1871†	Two years and nine months.
CHARLES H. ALLEN, elected January 4, 1871, to May 4, 1873	Two years and four months.
JOHN A. HAVEN, elected May 4, 1873, to Dec. 17, 1874†	One year and seven months.
THOMAS GOGIN, elected Dec. 17, 1874, and resigned May 31, 1875	Six months.
L. MILES STANDISH, elected August 5, 1875, to July 31, 1876†	One year.

Members of the Board.

THOMAS WETMORE, 1851, 52, 53, 54, and 55†	Five years.
JOHN H. WILKINS, 1851, 52, 53, *56, 57, 58, and 59†	Eight years.
HENRY B. ROGERS, 1851, 52, 53, *54, and 55†	Five years.
JONATHAN PRESTON, 1851, 52, 53, and 56†	Four years.
JAMES W. SEAVER, 1851†	One year.
SAMUEL A. ELIOT, 1851.†	
JOHN T. HEARD, 1851†	One year.
ADAM W. THAXTER, Jr., 1852, 53, 54, and 55†	Four years.
SAMPSON REED, 1852 and 1853†	Two years.
EZRA LINCOLN, 1852†	One year.
THOMAS SPRAGUE, 1853, 54, and 55†	Three years.
SAMUEL HATCH, 1854, 55, 56, 57, 58, and 61	Six years.
CHARLES STODDARD, 1854, 55, 56, and 57†	Four years.
WILLIAM WASHBURN, 1854 and 55†	Two years.
TISDALE DRAKE, 1856, 57, 58, and 59†	Four years.
THOMAS P. RICH, 1856, 57, and 58†	Three years.
JOHN T. DINGLEY, 1856 and 59†	Two years.
JOSEPH SMITH, 1856†	Two months.
EBENEZER JOHNSON, 1857, 58, 59, 60, 61, 62, 63, and 64†	Eight years.
SAMUEL HALL, 1857, 58, 59, 60, and 61†	Five years.
GEORGE P. FRENCH, 1859, 60, 61, 62, and 63†	Five years.
EBENEZER ATKINS, 1859†	One year.
GEORGE DENNIE, 1860, 61, 62, 63, 64, and 65	Six years.
CLEMENT WILLIS, 1860†	One year.
G. E. PIERCE, 1860†	One year.
JABEZ FREDERICK, 1861, 62, and 63†	Three years.
GEORGE HINMAN, 1862 and 63	Two years.
JOHN F. PRAY, 1862†	One year.
J. C. J. BROWN, 1862	One year.
JONAS FITCH, 1864, 65, and 66†	Three years.
OTIS NORCROSS, *1865 and 66†	Two years.
JOHN H. THORNDIKE, 1864, 65, 66, and 67†	Four years.
BENJAMIN F. STEVENS, 1866, 67, and 68	Three years.
WILLIAM S. HILLS, 1867	One year.
CHARLES R. TRAIN, 1868†	One year.
JOSEPH M. WIGHTMAN, 1868 and 69†	Two years.
BENJAMIN JAMES, *1858, 68, and 69	Three years.
FRANCIS A. OSBORN, 1869	One year.
WALTER E. HAWES, 1870†	One year.

JOHN O. POOR, 1870	One year.
HOLLIS R. GRAY, 1870	One year.
NATHANIEL J. BRADLEE, 1863, 64, 65, 66, 67, 68, 69, 70, and 71†	Nine years.
GEORGE LEWIS, 1868, 69, 70, and 71‡	Four years.
SIDNEY SQUIRES, 1871‡	One year.
CHARLES H. HERSEY, 1872	One year.
CHARLES H. ALLEN, 1869, 70, 71, and 72	Four years.
ALEXANDER WADSWORTH, *1864, 65, 66, 67, 68, 69, and 72	Seven years.
CHARLES R. MCLEAN, 1867, 73, and 74‡	Three years.
EDWARD P. WILBUR, 1873 and 74	Two years.
JOHN A. HAVEN, 1870, 71, 72, 73, and 74‡	Five years.
THOMAS GOGIN, 1873, 74, and 75*	Three years.
AMOS L. NOYES, 1871, 72, and 75	Three years.
WILLIAM G. THACHER, 1873, 74, and 75‡	Three years.
CHARLES J. PRESCOTT, 1875	One year.
EDWARD A. WHITE, 1872, 73, 74, 75, and 76‡‡	Five years.
LEONARD R. CUTTER, 1871, 72, 73, 74, 75, and 76†	Six years.
L. MILES STANDISH, 1860, 61, 63, 64, 65, 66, 67, 74, 75, and 76†‡	Ten years.
CHARLES E. POWERS, *1875 and 1876†‡	Two years.
SOLOMON B. STEBBINS, 1876†	One year.
NAHUM M. MORRISON, 1876†	One year.
AUGUSTUS PARKER, 1876†	One year.

* Mr. John H. Wilkins resigned Nov. 15, 1855, and Charles Stoddard was elected to fill the vacancy. Mr. Henry B. Rogers resigned Oct. 22, 1865. Mr. Wilkins was re-elected Feb., 1856, and chosen President of the Board, which office he held until his resignation, June 5, 1860, when Mr. Ebenezer Johnson was elected President; and July 2 Mr. L. Miles Standish was elected to fill the vacancy occasioned by the resignation of Mr. Wilkins. Otis Norcross resigned Jan. 15, 1867, having been elected Mayor of the City. Benjamin James served one year, in 1858, and was re-elected in 1868. Alexander Wadsworth served six years, 1864-69, and was re-elected in 1872. Thomas Gogin resigned May 31, 1875. Charles E. Powers was elected July 15, to fill the vacancy occasioned by the resignation of Mr. Gogin.

† Served until the organization of the Boston Water Board.

‡ Deceased.

BOSTON WATER BOARD,

Organized July 31, 1876.

TIMOTHY T. SAWYER, from July 31, 1876, to May 5, 1879; and from May 1, 1882, to May 4, 1883.

LEONARD R. CUTTER, from July 31, 1876, to May 4, 1883.

ALBERT STANWOOD, from July 31, 1876, to May 7, 1883.

FRANCIS THOMPSON, from May 5, 1879, to May 1, 1882.†

WILLIAM A. SIMMONS, from May 7, 1883, to Aug. 18, 1885.

GEORGE M. HOBBS, from May 4, 1883, to May 4, 1885.

JOHN G. BLAKE, from May 4, 1883, to Aug. 18, 1885.

WILLIAM B. SMART, from May 4, 1885, to March 18, 1889.

HORACE T. ROCKWELL, from Aug. 25, 1885, to April 25, 1888.

PHILIP J. DOHERTY, from March 18, 1889, to May 4, 1891.

THOMAS F. DOHERTY, from Aug. 26, 1885, to May 5, 1890; and from May 4, 1891, to present time.

ROBERT GRANT, from April 25, 1888, to present time.

JOHN W. LEIGHTON, from May 5, 1890, to present time.

ORGANIZATION OF THE BOARD FOR YEAR 1892.

Chairman.

ROBERT GRANT.

Secretary and Chief Clerk.

WALTER E. SWAN.

City Engineer and Engineer of the Board.

WILLIAM JACKSON.

Superintendent of the Eastern Division of Cochituate Department.

WILLIAM J. WELCH.

Superintendent of the Western Division and Resident Engineer of Additional Supply.

DESMOND FITZGERALD.

Superintendent of Mystic Department.

EUGENE S. SULLIVAN.

† Deceased.

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